JUN 1 8 1948

Research Quarterly

MAY, 1948

Volume 19
No. 2

Published by the

AMERICAN ASSOCIATION FOR HEALTH,
PHYSICAL EDUCATION,
AND RECREATION

A Department of the National Education Association

The Research Quarterly

of the American Association for Health, Physical Education, and Recreation

MARY WIBEL, *Editor*

MAY, 1948 Volume 19, No. 2

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Published in March, May, October, and December by the American Association for Health, Physical Education, and Recreation, 1201 Sixteenth Street, N.W., Washington 6, D. C. Subscription, $3.00 per year; single copies, $1.00.

Send subscription to: 1201 Sixteenth Street, N.W., Washington 6, D. C.

Editorial office: 1201 Sixteenth Street, N.W., Washington, D. C.

Entered as second-class matter at the Post Office at Washington, D. C., under the act of March 3, 1879.

Physical Efficiency Tests for College Women

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(Submitted for publication, March, 1948)

INTRODUCTION

PHYSICAL efficiency tests have been recommended to measure various phases of physiological functioning. The variations between different batteries reflect the philosophy of the investigators concerning that which is essential to efficient performance. For example, one battery may emphasize work of long duration, while another may be primarily concerned with the strength of certain muscle groups and another may emphasize such factors as agility, balance, flexibility, etc. Further consideration of the development of such batteries also reveals the thinking of the investigator in the type of criterion selected for test validation. These criteria vary from only subjective and empirical evaluation of tests to a composite of many items, to some objective, measurable physiological capacity.

For a number of years the authors of this study have been working on certain aspects of efficiency testing. A previous report (4) presented the validation of a battery for college women. The criterion was work output as measured on a bicycle ergometer. The ergometer gives reliable and objective scores on the work done, and therefore indirectly on the capacity of the subject to work hard for a brief period of time. The generated voltage is translated directly into kilogram-meters of work; this is not possible in other types of work estimates. The action of the legs is not unlike that in walking and running, and the subject is motivated more by seeing the recording of the ergometer than by performing of repetitive exercises or by running a treadmill. The ergometer also yields a relatively quick measure of work and is easier to secure all-out effort from girls of college age than on a measure of longer duration.

PURPOSE OF THE STUDY

The purpose of this study is four-fold:

1. To repeat the project previously reported (4) and so repeat the comparison of those tests (pull, obstacle race, bounce, sit-ups, chair stepping) with work output.

2. To present refinements which have been made in the pull test since the previous report.

3. To compare additional measures of strength with the experimental battery and with work output.

4. To present T-scales for college women on the items in the experimental battery.

All tests were administered in the same way as for the previous study (4) except that chair stepping and sit-ups were scored as *total movements for one minute* (movement up counted as 1, down, as 1). This was based on recommendations from the previous study and later work with the tests.

The work output was measured on the bicycle ergometer with subjects working at maximum effort for one minute. This is the same as previously except that the work was for one minute's duration instead of two. This change was based on findings of an unpublished study by Tuttle and Wilson (5).*

PROCEDURE

The student did all five tests of physical efficiency in a single session, several students performing at the same time. At that time volunteers were given individual appointments for the measurement of work. Each appointment came within the next two or three days following the first testing period. At the time of the bicycle ride additional measures were taken: grips, push-pull, back strength, leg strength, height, and weight. Forty-five subjects took the entire series of test items. An additional eight subjects took all the tests in the second series but not those in the first. Computations are, therefore, on forty-five or fifty-three subjects.

The subjects in the study previously reported will be known henceforth as Group A, those in this study, as Group B.

No repetition of reliability computation was made, since all test items had previously undergone a series of such treatments.

Statistical treatment followed the same pattern as in the previous report: r between each item and criterion score, intercorrelations, multiple correlations.

Surface area was determined from the DuBois nomogram (1) based on weight and standing height.

The tests have been in use for the past four years with college freshmen and sophomore women. T-scales have been computed on each test and the total of the T-scores for the five items has been used as the efficiency measure. Therefore, the sum of the T-scores is included in this report.

DISCUSSION OF DATA

Table I presents all zero-order correlations. The r's in the first column, total work output, are validity coefficients. The results are

*For a group of 172 women, the r between one minute and two minutes of work was .94.

similar to the previous study. The comparison of each test in its relationship to work output is as follows:

Test	*Group A*	*Group B*	*Difference*
Obstacle run	.529	.479	—.050
Vertical pull	.486	.352	—.134
Sit-ups	.482	.522	+.040
Bounce	.448	.450	+.002
Chair stepping	.372	.580	+.208

The only differences of any size are on vertical pull and chair stepping. The pull drops from better than a 1 percent level of confidence to about a 2 percent (2) level on Group B. The chair stepping while previously at approximately the 1 percent level of confidence shows marked improvement.

The drop in the pull tests is probably due to the difficulties of administration and the resulting unreliability. The main problem in administration has been to get subjects to avoid body sway while pulling and to get adequate fixation of the trunk. The former tends to increase scores and the latter to decrease scores. Different assistants gave the test to Groups A and B. These difficulties indicated a need for improvement of the form in which the test is given. This change is discussed later.

Intercorrelations between these five items are insignificant except in the case of chair stepping with three of the tests, obstacle run, bounce, and sit-ups; and between the bounce and two, obstacle and sit-ups. These are similar to results on Group A.

TABLE I

COEFFICIENTS OF VALIDITY AND OF INTERCORRELATION

	Total Work	*Pull*	*Obstacle race*	*Bounce*	*Sit-ups*	*Chair Step*	*Sum T-Scores*	*Weight*	*Height*
Total work								.490	.329
Vertical pull	.352							.377	.423
Obstacle race	.479	.076						—.135	—.055
Bounce	.450	.286	.557					—.046	.050
Sit-ups	.522	.248	.371	.516				.026	.049
Chair stepping	.580	.147	.637	.495	.581			—.055	—.003
Sum T-scores	.659	.553	.699	.770	.725	.764		.103	.218
Left grip	.438	.623	.305	.385	.215	.260	.513	.387	.491
Right grip	.479	.558	.273	.427	.355	.329	.564	.332	.412
Push and Pull	.471	.380	.416	.521	.335	.250	.543	.376	.285
Back strength	.183	.498	.053	.153	—.036	—.060	.231	.337	.403
Leg strength	.487	.361	.191	.258	.236	.303	.430	.407	.281
Surface area	.466	.449	—.071	.005	.036	—.050	.163	.957	

The correlation of .66 between the sum of T-scores and total work is in close agreement with the previous report which gave a multiple coefficient of .70 between the five items and two minutes of bicycle riding.

All strength measures except back strength yield significant correlations with the criterion. Grips and back strength have greatest

relationship with the pull test. Coefficients between the right grip and the efficiency battery items, while not always higher than those of the left, seem to be more consistent than those of left grip. This may be the result of right-handedness of most of the group and greater individual range in left grip. However, the correlation between grips is .83.

In these data, there is some relationship between size of subject and total work output: weight, .490, height, .329, and surface area, .466. These are considerably larger than in previous studies, however. For example, Tuttle and Wilson (6), in an unpublished study, obtained an *r* of .234 between surface area and work for two minutes for a group of 146 women. Likewise, Meerdink (3) reported an *r* of .150 for 65 women on the same measures.

However, there is no significant relationship between size and any of the efficiency items except the pull test: weight, .377, height, .423 and surface area, .477. In this respect the coefficients are in close agreement with previous reports.

The multiple correlations of various combinations of tests were computed. Coefficients are given in Table II. Some three-item combinations are approximately as good as four or five items. Similarity of coefficients for three-, four-, and five-item combinations are largely the result of some relationship between the respective items.

TABLE II

MULTIPLE CORRELATION OF EFFICIENCY ITEMS WITH CRITERION OF WORK OUTPUT

	R
Two-Item Combinations	
Chair stepping, sit-ups	.634
Obstacle race, sit-ups	.606
Three-Item Combinations	
Push-pull, chair stepping, sit-ups	.688
Vertical pull, chair stepping, sit-ups	.666
Right grip, obstacle race, sit-ups	.663
Vertical pull, obstacle race, sit-ups	.650
Left grip, obstacle race, sit-ups	.648
Vertical pull, obstacle race, chair stepping	.628
Four-Item Combinations	
Push-pull, sit-ups, bounce, chair stepping	.687
Vertical pull, sit-ups, bounce, chair stepping	.669
Right grip, obstacle race, sit-ups, bounce	.663
Left grip, obstacle race, sit-ups, bounce	.659
Vertical pull, obstacle race, sit-ups, bounce	.651
Vertical pull, obstacle race, sit-ups, chair stepping	.640
Five-Item Combinations	
Right grip, obstacle race, sit-ups, bounce, chair stepping	.691
Vertical pull, obstacle race, sit-ups, bounce, chair stepping	.689
Push-pull, obstacle race, sit-ups, bounce, chair stepping	.686
Left grip, obstacle race, sit-ups, bounce, chair stepping	.678

These coefficients are very similar to the corresponding ones on Group A. Likewise, the general conclusion from both studies would indicate the advisability of using a four-item battery for maximum value and economy of testing time.

The choice of a particular four or five items must depend upon the analysis of the tests and the value to students training for the tests. For example, the choice which has been made where this battery has been in use is for the five items including the vertical pull. The development of the muscles of the shoulder girdle and shoulder seems more important than that of the finger flexors which are measured in the grip test. The chair stepping was also included because it is the only item in the battery which demands general endurance to the point that it is apparent to the student. From the standpoint of motivation it appeared to possess values beyond those set up statistically.

Change in Vertical-Pull Test

Additional work on the vertical-pull test since data for this study were collected has led to greater reliability than in the older form. Instead of the spring scale, a dynamometer with push-pull attachment is fastened to an adjustable cross bar. The subject stands with back against the wall. No sway or body weight is permitted in this position. The pointer on the dynamometer also remains in place facilitating reading; the spring scale must be read at its highest point. It is probable, therefore, that the pull test given in this way would yield a coefficient with work at least as high as that obtained on Group A, and that the total battery would be improved somewhat.

The question was raised as to the possibility that there is a chinning effect in the test. If such were the case there should be value in fastening the feet down. Therefore, a group of fifty subjects were given the test in five forms: spring scale—feet free, and feet held; dynamometer—feet free, feet held, and back firm against the wall but with feet free. The following correlations give the answer to the value of anchoring the subjects and indirectly on the comparative reliability of the test given on the two pieces of equipment.

	r
Spring—feet free, feet held	.69
Dynamometer—feet free, feet held	.80
Dynamometer—feet free, back on wall	.82
Dynamometer—feet held, back on wall	.90

The mean increase with feet held on a spring scale was 4.7 with a range from a gain of 20 to a loss of 6. However, on the dynamometer the mean gain from having feet anchored was 1.4, while holding back against the wall gave a mean loss of .5. This evidence led to the replacement of the spring scale form of the test

by that with the dynamometer, administered with back firm against the wall and subject stretching tall. The extra time to strap the feet down does not appear to be justified. The change in equipment and position seems to have removed most of the possibility of body sway and hence use of body weight, and also to have improved reliability of the test.

T-Scales

These tests have been in use with freshmen and sophomore women at the University of Iowa for four years. T-scales have been established on their performance and are presented here for possible use with other groups of students. Scales presented for the vertical pull are on both pieces of equipment. The dynamometer has been used only during the current year and hence the scale on this form is less stable than the other. The scores on the dynamometer are larger than on the spring scale because the pull is registered directly on the dynamometer. In using the spring scale the rope goes up through a pulley and then down to the scale; a great deal of the pull is lost in friction.

TABLE III

Efficiency T-Scales

T-Score	*Bounce*	*Sit-up*	*Chair Stepping*	*Obstacle Race*	*Dynamometer Pull*	*Spring Scale Pull*	*T-Score*
84	325				120		84
83	300	100			115		83
82	280		165	17.0-17.4	112	92	82
81	260	96	162		110	91	81
80	250		160	17.5-17.9	107	89	80
79	245	95	157		103	87	79
78	240		154		100	84	78
77	235	94	153		96	81	77
76	230		151		94	80	76
75	225	93	150	18.0-18.4	93	79	75
74	220		149		92	78	74
73	215	92	148		91	77	73
72	210	91	146	18.5-18.9		76	72
71	205	90	142		90	75	71
70	200	88-89	141		89		70
69	195	87	139	19.0-19.4	88	74	69
68	190	86	138			73	68
67	185	85	137		87	72	67
66	180	84	136		86	71	66
65	175	82-83	134	19.5-19.9	85	70	65
64	170	80-81	132		84	69	64
63	165	79	130		83	68	63
62	160	77-78	128	20.0-20.4	82	67	62
61	155	75-76	127		81	66	61
60	150	74	126		80	65	60

T-Score	*Bounce*	*Sit-up*	*Chair Stepping*	*Obstacle Race*	*Dynamometer Pull*	*Spring Scale Pull*	*T-Score*
59	145	73	124	20.5-20.9	79	64	59
58	140	72	122		78	63	58
57	135	71	121		77		57
56	132	70	120	21.0-21.4		62	56
55	128	69	118		76		55
54	124	68	117	21.5-21.9		61	54
53	120	66-67	116		75	60	53
52	116	65	114		74	59	52
51	113	64	112	22.0-22.4	73	58	51
50	110	63	110		72	57	50
49	108	62	108		71	56	49
48	106	61	106	22.5-22.9	70	55	48
47	104	59-60	105		69		47
46	102	58	104		68	54	46
45	100	57	102	23.0-23.4		53	45
44	98	56	100		67		44
43	96	54-55	98	23.5-23.9		52	43
42	94	53	96		66		42
41	92	52	94	24.0-24.4	65	51	41
40	90	50-51	92		64	50	40
39	87	49	90			49	39
38	84	48	88	24.5-24.9	63		38
37	81	47	86		62	48	37
36	78	46	84			47	36
35	72	45	82	25.0-25.4	61		35
34	70	43-44	80	25.5-25.9		46	34
33	68	42	78		60		33
32	65	40-41	74	26.0-26.4		45	32
31	62	39	72	26.5-26.9	59		31
30	60	37-38	70			44	30
29	58	36	69	27.0-27.4	58		29
28	55	35	68	27.5-27.9		43	28
27	52	34	67		57		27
26	50	33	66		56	42	26
25	47	31-32	65	28.0-28.4	55	41	25
24	43	30	63		54	40	24
23	40	29	62	28.5-28.9	53	39	23
22	37		60		52		22
21	33	28	58			38	21
20	30	27	54	29.0-29.4	51		20
19	28		52		50	39	19
18	27		50		49		18
17	26	26	48	29.5-29.9	48	36	17
16		25	45	30.0-30.5			16

CONCLUSIONS

This study is in close agreement with the previous report. The following conclusions appear justified.

1. No single item in the battery has a high enough relationship to work output to justify use of any single item. Each item has a significant relationship, however.

2. The batteries of four items have predictive value equal to that of the five-item batteries. These correlations are strikingly similar to corresponding coefficients obtained in the previous study on an entirely different group of 82 subjects.

3. The pull test is the only test in the experimental battery (pull, obstacle race, bounce, sit-ups, and chair stepping) with any relationship to the measures of body size, i.e., height, weight, and surface area. The pull test does show significant relationship with size and is similar in this respect to the other strength tests. There is some evidence that the pull test has been refined to eliminate at least part of the advantage gained from weight.

4. The sum of T-scores on the items is a satisfactory way of combining the test scores.

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Selection of Women Major Students in Physical Education

By Anna Espenschade

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(Submitted for publication, January, 1948)

THE early discovery and selection of promising candidates for teaching in physical education has been the subject of several investigations. The value of such seection both to the profession and to the individual contemplating a career in the field is obvious. But little headway has been made to date toward a solution of the problem.

The qualities necessary for success have been analyzed and investigators agree upon them fairly well (1, 5, 7, 8). They may be grouped under four headings and arranged in order of importance as follows: (1) personality and character, (2) health and motor ability, (3) intelligence and scholarship, (4) personal appearance.

Although the measurement of personality by means of questionnaires is of doubtful validity (4), three studies in physical education have found the Bernreuter inventory adequate to distinguish between groups. Duggan (3) compared a group of undergraduate women students majoring in physical education with undergraduates majoring in other fields and found that the physical education group showed greater emotional stability, were more extraverted and dominant. More successful teachers of physical education were compared with less successful teachers by Palmer (9). She matched fifty pairs on the basis of training institution and year of graduation and compared their scores on the Bernreuter inventory. The more successful teachers showed greater emotional stability, were more extraverted and dominant. Gross (6) gave a slightly modified form of the Bernreuter test to physical education major students. More successful and less successful major groups were selected on the basis of scholarship, motor skills, leadership, personal appearance, and ratings of probable success in teaching. Emotional stability, extraversion, dominance, and self-confidence were significantly related to success.

The interests of individuals reveal certain personality traits and have been found especially useful in vocational guidance. Duggan (3) found significant differences in interests between physical education majors and undergraduates majoring in other fields. Neither Palmer (9) nor Gross (6), however, were able to distinguish be-

tween groups of physical education teachers or of major students on the basis of interests.

The other qualities listed above as important for success in teaching physical education are more readily assessed than is personality. Health may be evaluated by a medical and physical examination; motor ability can be measured by selected tests; scholarship may be observed by the end of a year in college; personal qualities can be reliably rated (10).

The present study is a continuation of the Gross study referred to above. Additional physical education students were tested and graduates who received teaching credentials and obtained teaching positions in the secondary field were followed up. Ratings of their teaching success were made by the school principal toward the end of their first year of teaching. These ratings provided the criterion for the further evaluation of data.

Mean scores on the Bernreuter scale for successive groups of physical education major students were almost identical (Table I). An examination of the interrelationships among traits showed the number of independent scales to be four, at most, B1N, B2S, B4D, F2S (B1N correlated with B1I .897 and with F1C .935). These may be described as emotional stability,* self-sufficiency, dominance, sociability, respectively. Of these four, dominance is rather highly related to emotional stability and the sociability and self-sufficiency scales show a fair degree of correlation (Table II). Because these latter two scales exhibit different patterns of relationship with emo-

TABLE I

MEAN SCORES ON THE BERNREUTER INVENTORY AND STRONG VOCATIONAL INTEREST BLANK

	NO.	B1N	B2S	B3I	B4D	F1C	F2S	Voc. Int.
College Wom. (Bernreuter)		— 42.8	6.8	—14.7	30.6	8.7	—31.1	
Adult Women (Bernreuter)		— 27.6	3.2	—15.8	18.4	— 1.0	—18.8	
More-Suc. (Gross)	18	—136.9	35.2	—73.5	100.5	—91.5	—37.2	104.4
Less-Suc. (Gross)	18	— 62.9	14.0	—32.8	41.6	—21.9	—22.6	99.1
U. C. 1943	80	— 86.8	5.7	—52.7	62.9	—40.8	—64.5	100.4
U. C. 1944	40	— 93.3	4.7	—51.3	62.0	—41.5	—63.7	102.8
U. C. 1945	50	— 92.4	3.1		62.1		—64.0	91.8

*A minus score is indicative of emotional stability.

TABLE II

TABLE OF INTERCORRELATIONS, INCLUDING RELIABILITIES

		1	2	3	4	5
1	Interests	.82	—.26	—.22	.21	—.48
2	Neurotic Tendency (B1N)		.89	—.40	—.74	.22
3	Self-sufficiency (B2S)			.71	.53	.61
4	Dominance (B4D)				.87	.20
5	Sociability (F2S)					.83

tional stability and dominance, both were retained for further study. The results show that the typical physical education major tends to be more stable emotionally, more dominant and sociable than the average college or adult woman.

The Strong Vocational Interest Blank, scored according to the Collins (2) key for women physical education majors was given to all students, although it was known to be of doubtful value within the major group.

Medical and physical examination records of the majors were too uniformly good to permit subdivision. The group must be considered homogeneous in relation to health.

Grades in academic classes and in physical education activities were used as measures of academic aptitude and of motor ability, respectively.

Ratings of probable success in teaching and of such personal qualities as voice, appearance, poise, and vitality were made by seven women instructors, each of whom had had twenty or more years of teaching experience. Thirty-three cases were rated by all seven. The average correlation of each rater with the total is given in Table III. These coefficients are very high for ratings and may be considered wholly satisfactory for group comparison although somewhat questionable for individual diagnosis.

Selective factors are operating continuously throughout the college course so that a relatively small percentage of students complete the five-year program for the teaching credential. Of those who enter as freshmen planning to major in physical education, for example, only 40 percent graduate from college in this program (Table IV). About half of the sophomores, two-thirds of the juniors, and all of

TABLE III

RATING OF PERSONAL QUALITIES

Average correlations of ratings of individual judges with total ratings of 7 judges

Voice	a) vocalization	.805
	b) articulation	.614
Appearance	a) physique	.807
	b) clothing	.747
Poise		.785
Vitality		.759

TABLE IV

PERCENTAGE OF STUDENTS OBTAINING TEACHING CREDENTIAL

Year of tests	*No.*	*A.B. degree*	*Teaching Cr.*
Freshman	41	41%	——*
Sophomore	42	48%	29%
Junior	39	67%	31%
Senior	23	100%	44%
Graduate	25	100%	100%

*Some students still in college.

the seniors graduate. Only a fraction of these graduates continue for the teaching credential. The most obvious selective factor here is academic aptitude. The critical ratio of the difference in grade point average between the teaching group and those who leave college is 7.99. Differences are significant at the .01 level in ratings of probable success and at the .05 level in personal qualities. There are no differences in measures of personality, interest, or activity grades (see Table V). The importance of such additional factors as economic status, home conditions, departmental advising, and the like cannot be estimated.

Ratings of teaching success and of emotional stability, honesty, integrity, sociability (interest in people), leadership, personal appearance, professional interest and attitudes, knowledge of subject matter, vitality and energy were made by principals or department heads on a five-point scale. A letter was sent to the principal explaining the purpose of the study and the confidential nature of the ratings. A one-hundred percent response was obtained. The reliability or comparability of these ratings cannot be estimated. Although the criterion is admittedly weak, no other measure of success could be obtained. In defense of the ratings it should be recognized that these principals are experienced raters and that they did not return uncritical reports obviously influenced by "halo."

The ratings were used in two ways: (1) groups were formed on the basis of ratings on success in teaching, and (2) a total score combining all other ratings was used in correlational study.

According to these ratings, there were 12 superior, 18 outstanding, and 16 average teachers. The superior teachers differed at the .01 level from the other two groups in ratings of probable success

TABLE V

MEAN SCORES OF CERTAIN GROUPS ON TESTS AND RATINGS

		Bernreuter					*Gr.*	*Act.*	*Prob.*	*Per*
	No.	*B1N*	*B2S*	*B4D*	*F2S*	*Int.*	*Pt.*	*Gr.*	*S*	*Q*
Sup. Teach.	12	-117.4	18.0	71.7	-64.4	108.0	1.95	2.89	5.56	33.5
Outst. Tch.	18	-79.0	1.9	55.0	-61.0	104.0	1.69	2.93	4.78	26.6
Av. Teach.	16	-91.0	14.4	65.8	-37.4	109.0	1.67	2.69	4.69	23.5
All Teach.	46	-93.6	10.4	63.1	-54.1	107.2	1.79	2.97	4.93	28.4
A.B. only	33	-90.7	4.8	64.8	-12.1	96.6	1.33	2.96	3.70	25.6
Dropped	48	-76.5	-4.6	56.7	-65.3	96.5	.96	3.00	3.69	25.4

TABLE VI

CORRELATIONS OF TEACHING SUCCESS WITH OTHER MEASURES

0 =	teaching success				
1	interests	r01	.071		
2	emotional stability	r02	.087		
3	self-confidence	r03	—.226		
4	dominance	r04	.104		
5	sociability	r05	.278		
6	grade points	r06	.115		
7	activity grades	r07	.245	Ro.78	.490
8	probable success	r08	.475	Ro.89	.475
9	personal qualities	r09	.361		

and of personal qualities. Differences between the outstanding and average teachers were significant only in ratings of personal qualities. Mean scores in all measures are given in Table V.

All correlations between principals' ratings and other measures were low (Table VI). However, the homogeneity of the group must be considered in interpreting these coefficients. Because of the fact that the basis of restriction in range is from multiple factors, no adequate statistical formula for correcting these coefficients is known (11). Because the small teaching group is as variable as the large unselected group of undergraduate majors in personality traits and interests, it is doubtful that correlations of these measures with teaching success would be changed by correction for range. Thus it must be concluded that personality and interests as measured are not related to teaching success. Ratings of probable success have the highest validity, followed in order by activity grades, ratings of personal qualities and grade-point average. The best combination of these measures (probable success and activity grades) yields a multiple correlation of R.490.

The records of Gross' more successful and less successful students may be examined with profit. As students, these groups were significantly different in grade-point average, motor skills, and ratings of probable success. Critical ratios of approximately 2 were found in emotional stability and in ratings of personal qualities. Approximately three-fourths of the more successful students and one-seventh of the less successful students became teachers (Table VII). Among these teachers, the chances are 96 in 100 that a more successful student will be a more successful teacher than will a less successful student.

SUMMARY AND CONCLUSIONS

Physical education majors who continue in the course and obtain the teaching credential differ significantly from those who drop out in grade-point average, and in ratings by teachers on probable success and personal qualities.

TABLE VII

COMPARISON OF MORE SUCCESSFUL WITH LESS SUCCESSFUL STUDENTS

	More Successful (no. 11)	*t*	*Less Successful* (no. 14)
A. B. degree	100%		64%
Teachers Creden.	73%		14%
Rating (Principals)			
Success: superior	75%)		(———
outstanding	12.5%)	2.32*	(———
average	12.5%)		(100%
Total (av.)	37.1	6.80**	26.5

* significant at .04 level.
** significant at .001 level.

Less successful students differ from more successful students in these same measures, and in addition, in activity grades and emotional stability.

Superior teachers differ from outstanding or average teachers in ratings of probable success and of personal qualities. Success in teaching correlates significantly with these ratings and also with activity grades.

In selecting students for teacher training, then, grades in academic classes, in physical activity classes, and ratings by teachers of probable success and of personal qualities are of value. The best single measure for the prediction of success in teaching is rating of probable success. The addition of grades in physical activity classes increases the efficiency of prediction slightly. Personality traits and interests as measured in this study are not related to teaching success.

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Contributions of Dr. Sargent to Physical Education

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THE extent and importance of Dudley Allen Sargent's life-time efforts have been evaluated at various times by competent authorities. In 1891, James Boykin wrote:

> If the work of Dr. D. A. Sargent, the director of the Hemenway Gymnasium, at Cambridge, Massachusetts, were expunged from the field of gymnastics it would be found that America's original contributions to the cause of physical training have been lamentably few.[1]

At the time of his death, the *New York Times* called him "America's pre-eminent leader in the field of physical education."[2] In the opinion of the talented Dr. R. Tait McKenzie, Dr. Sargent "influenced physical education more than any man of his time—in the training of teachers, in the invention of apparatus, and in the spreading abroad of the gospel of sound physical education . . ."[3] The late Dr. William G. Anderson stated that Sargent did more than any other American to create and arouse sane and rational interest in physical education.[4] The influence of Dr. Sargent's work is measured by this statement in the *Dictionary of American Biography:*

> During the forty years in which he held the position [at Harvard], he exerted a greater influence on the development of physical training in American colleges and schools than any other man.[5]

These statements help provide a general idea of Dr. Sargent's role in the development of physical education from 1870 to the present day. Let us now examine the facts in more detail.

This is a chapter from *The Life of Dudley Allen Sargent, M.D., and His Contributions to Physical Education*, a dissertation submitted in partial fulfillment of the requirements for the degree of doctor of philosophy at the University of Michigan, August, 1947.

1James C. Boykin, "Physical Training." 1, p. 549, *Report of the Commissioner of Education for 1891-92.* Washington: Government Printing Office, 1894.

2July 23, 1924.

3R. Tait McKenzie, "Pioneers in Physical Education," *Journal of Health and Physical Education*, 2:9 (November, 1931), p. 7.

4Letter to author, October 14, 1946. Dr. Anderson passed away July 7, 1947.

5XVI, p. 355.

The content of such college physical education programs as existed in 1870 was poor and unsuited to the needs of the students. The gymnasium was inhabited only by the strong and athletic students who performed on the gymnastic apparatus, or used heavy iron dumbbells and lifting machines. In the unique system of physical training at Amherst, directed by Dr. Edward Hitchcock, it is important to note that these class exercises were mainly recreative and hygienic, and the few anthropometric measurements taken by Dr. Hitchcock were for purposes of comparison and motivation. In Dr. Hitchcock's own words, these measurements were taken to ascertain the average man and were "secured mainly for anatomical and physiological science, and to allow the student by annual comparisons to see what his development might be."[6] The measurements of every new student entering college were recorded and the examination repeated each year thereafter.

Coming to Harvard in 1879, Dr. Sargent made the first significant advance in college physical education since 1861 when Dr. Hitchcock went to Amherst. Sargent's principles and methods were based on a scientific procedure to meet individual needs. In the first place, a medical man was necessary to direct the program. No longer could an ex-prizefighter or janitor run the gymnasium. Each student received an individual examination which consisted of two parts—the medical and the physical. The first part comprised an examination of the heart and lungs and sometimes sight and hearing, and a record of personal and family history of diseases. The physical examination consisted of about forty anthropometrical measurements and strength tests. On the basis of this inclusive examination, each student received an individual prescription for exercise designed to remedy his own particular defects and build up his body when necessary. Since the average student did not have the physical strength to properly use the gymnastic apparatus, Dr. Sargent devised his own apparatus and modified others so that they could be adjusted to the ability of the weakest student. After working on his own exercises for three to six months, the student was entitled to another examination to check his progress and perhaps receive another prescription.

Dr. Sargent's appliances and principles were eagerly accepted by schools all over the country after 1880. In 1885 Hartwell listed forty-nine colleges, schools, YMCA's, and athletic clubs which had wholly or partially furnished their gymnasiums with Dr. Sargent's apparatus since 1879.[7] Sixteen of these institutions employed his

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6Edward Hitchcock, "Athletics in American Colleges," *Journal of Social Science*, XX (June, 1885), p. 41.

7Edward M. Hartwell, *Physical Training in American Colleges and Universities*, pp. 56-7. Bureau of Education Circular of Information No. 5, 1885. Washington: Government Printing Office, 1886.

system of measurements and directions. At the physical training conference in 1889, Sargent stated that 350 institutions were using his apparatus.[8] By 1893, the total had jumped to 740 gymnasiums, which included 263 schools and colleges, 310 YMCA's, 72 athletic clubs, and 95 others.[9] Hartwell estimated that seventy percent of all gymnasiums constructed between 1881 and 1893 were equipped with some of the Sargent appliances.[10]

These cold statistics are enlivened by various notes from other sources. For example, an item in *Outing* magazine said that the new gymnasium of the Rochester Athletic Association was equipped with the Sargent apparatus made under his personal supervision.[11] Sargent apparatus was installed in the new gymnasium of the State Reformatory at Elmira, New York.[12] At the Boston Conference, Dr. Whittier, director of the Bowdoin gymnasium, stated that Bowdoin used the Sargent method in its entirety.[13] A gymnasium was established in the new Latin and English High School building in Boston in 1881 in accordance with Dr. Sargent's ideas.[14] Sargent appliances were used at Yale.[15]

An interesting illustration of the spread of the Sargent principles occurred at the University of California. A young army officer, Lt. George Harrison, was concluding his duty as a drill instructor at the University and was invited to make a report to the Board of Regents. He described the Sargent apparatus and then wrote:

> Therefore, no college gymnasium will be properly equipped which is not provided with said apparatus, and no course of instruction entirely practicable which does not provide for its use.[16]

The report evidently impressed the Regents because a Department of Physical Culture was established in September, 1888, with a two-year physical education requirement. The University purchased apparatus direct from Dr. Sargent and appointed Dr. F. H. Payne as director.[17]

8Isabel C. Barrows, editor, *Physical Training*, pp. 64-5. Boston: George H. Ellis Press, 1890.

9*Report by Dr. D. A. Sargent*, p. 26. Boston: Alfred Mudge and Son, 1897.

10Sargent, "The Physical State of the American People," II, p. 467, *United States of America*, N. S. Shaler, editor. New York: D. Appleton and Company, 1894.

11*Outing*, IV (August, 1884), p. 389.

12Hamilton D. Wey, "Physical Training of Criminals," National Education Association *Journal of Proceedings and Addresses*, XXXII (1893), p. 649.

13Barrows, *op. cit.*, p. 84.

14Boykin, *op. cit.*, p. 535.

15William G. Anderson, "Physical Training at the Universities," *Cosmopolitan*, XXI (May, 1896), 61-9.

16George F. E. Harrison, *Report on Physical Training*, submitted to Board of Regents, University of California, June 26, 1888, p. 10. Sacramento: J. D. Young, Superintendent of State Printing, 1888.

17*Annual Report of the Secretary to the Board of Regents of the University of California*, for the Year Ending June 30, 1899, pp. 74-6, 239, Sacramento: State Office, 1889; also for following year, pp. 207-8.

The Sargent principles and apparatus were widely adopted by the leading colleges for women, many of whom employed Sargent Normal School graduates. Sargent apparatus was mentioned at Wellesley in 1882, Bryn Mawr and Rockford in 1884, Vassar and Mt. Holyoke in 1889, and Wells College at Aurora, New York, in 1890.[18] Dr. Sargent personally supervised the physical training of the Radcliffe girls until 1892. Sargent-trained instructors served at all the above schools plus Goucher and Barnard.[19] Mills College in California bought apparatus from Sargent.[20] On the basis of her study, Ainsworth states that the Sargent theory of individual work was most popular in colleges for women between 1881 and 1900.[21]

The geographical boundaries of the United States proved no barrier to the spread of the Sargent appliances. Sargent's good friend, R. Tait McKenzie, a graduate of McGill University, helped introduce Sargent's methods into Canada. In 1889 Sargent inquired about shipping rates to London for five boxes of gymnastic apparatus.[22] An English writer two years later thought that the only gymnasium in England or Europe with Sargent's apparatus was the Royal Normal College in Upper Norwood, S.E.[23] A prospectus of a gymnasium in Liverpool under the auspices of the YMCA described various special appliances of the Sargent type.[24] In 1894, Sargent reported that his apparatus was used in two gymnasiums in the West Indies, one in Mexico, sixteen in Canada, three in England, and one in Australia.[25] It is obvious that Europe and the Scandinavian countries with the German, Swedish, and Delsarte systems had no place for Sargent apparatus.

The official report of the Commissioner of Education for 1891-92 sums up Dr. Sargent's influence in the United States in these words: "The athletic clubs, the Young Men's Christian Association, and most of the college gymnasiums have adopted Dr. Sargent's ideas very largely, . . ."[26] However, the public schools made little use of the Sargent theory and apparatus. In this same report,

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18Dorothy Ainsworth, *History of Physical Education in Colleges for Women*, p. 40. New York: A. S. Barnes & Company, 1930.

19*Ibid.*, p. 51.

20L. H. Betts to Mrs. Mills, August 27, 1890 (Harvard Archives). In this letter, Betts, who was Dr. Sargent's secretary, enclosed an invoice and bill of lading for apparatus ordered by Mrs. Mills, the principal of Mills College.

21Ainsworth, *op cit.*, p. 18.

22Sargent to C. Furness, October 7, 1889 (Harvard Archives).

23Guy M. Campbell, *Dr. Sargent and the American System of Physical Culture*, p. 12. London: Dunn, Collins, and Company, 1891. This is a reprint from *The Gymnast*, for June, August, September, October, 1891.

24*Prospectus of Liverpool Gymnasium*, under auspices of YMCA, 1892-93.

25Sargent, "The Physical State of the American People," II, p. 467, *United States of America*, editor N. S. Shaler.

26Boykin, *op. cit.*, p. 549.

Ypsilanti, Michigan, was the only city out of 165 listed which used the Sargent methods.[27] Since Ypsilanti also reported that it had no gymnasium, used no apparatus, and had only ten-minute physical training periods, it is difficult to see just what Ypsilanti teachers could accomplish with Sargent's methods. Swedish gymnastics were much better adapted to conditions existing in the public schools for several reasons:

1. Movements were executed on command, and the form of movement was stressed. These features fitted in nicely with the disciplinary concept of education prevailing at the time.

2. Swedish movements were arranged in a strict progression from day to day and year to year.

3. No apparatus was required and exercises could be done in an ordinary classroom.

4. No bath was necessary after a Swedish gymnastics lesson. Water was supposedly evaporated through the lungs by respiratory exercises and thus skin evaporation was greatly reduced.[28]

Throughout cities in the Mid-west, the German syetem was very popular. Military drill was also used throughout the country, especially in high schools. Dr. Sargent made no particular effert to adapt his principles for use in the public schools and perferred to direct his attention to colleges as he thought he could wield greatest influence there.

After purchasing apparatus, many schools felt no obligation to employ a competent teacher or director. This condition was set forth by Hartwell:

> Whatever the reason for this state of things, the fact is obvious that our colleges and secondary schools, with few exceptions, have shown vastly more skill and energy in the acquisition of mere appliances than they have in developing the science and art of physical education.[29]

From about 1900 on, athletic sports furnished more and more competition for the Sargent apparatus and exercises which began to lose their former influence. A survey of public normal schools in 1906 showed that only eight out of thirty-six directors gave the Sargent physical examinations though some others used similar

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27*Ibid*, pp. 580-93.

28Nils Posse, "How Gymnastics are Taught in Sweden," quoted in Boykin, *op. cit.*, p. 539.

29Edward M. Hartwell, "On Physical Training," I, p. 558, *Report of Commissioner of Education for 1897-98*, 2 vol. Washington: Government Printing Office, 1899.

ones, and only two schools out of over one hundred used the Sargent exercises.[30] Many schools and colleges used the Sargent individual exercises along with other class activities. Even in his own normal school and the Harvard Summer School, Dr. Sargent no longer devoted much time to the use of his apparatus. Yet Bowdoin continued with the Sargent examinations and exercises to 1924,[31] and the strength test was not discarded in many schools until 1915.[32] Today only the chest weights have survived while most of the other Sargent appliances are now regarded as antiques.

With reference to the pulley-weights, McKenzie stated that Sargent was responsible for the improvement of the design, their systematic application to gymnastic training, and their wide employment in physical education.[33]

The Sargent exercises, used alone, had several deficiencies which were pointed out by various medical men. Dr. Hartwell stated the Sargent apparatus only enlarged and strengthened the muscles without teaching skill and discrimination to the nerve centers which animate the muscles.[34] Dr. McKenzie recognized that powerful muscular development could be attained without an accompanying capacity for prolonged exertion. Furthermore, the exercises lacked interest.[35]. The corrective and hygienic results of the apparatus were admitted by Dr. Leonard but he emphasized the lack of recreative and educational qualities.[36]

Sargent himself saw that a man who has developed one part of the body after another may be unable to produce continued application of power.[37] But he never boasted of having a complete system of exercise and always proclaimed the necessity of games and sports along with the apparatus exercises.

Sargent's anthropometrical measurements and examination were widely used throughout the United States and extended to other

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30George B. Affleck, "Status of Physical Training in Public Normal Schools in the United States," *American Physical Education Review*, XI (December, 1906), pp. 264-73.

31Louis C. Hatch, *History of Bowdoin College*, p. 381. Portland, Maine: Loring, Short, and Harmon, 1927.

32John F. Bovard and Frederick W. Cozens, *Tests and Measurements in Physical Education: 1861-1925. A Treatment of the Original Sources with Critical Comment*, p. 7. University of Oregon Publication, Physical Education Series, I (September, 1926), pp. 1-94.

33R. Tait McKenzie, *Exercise in Education and Medicine*, pp. 364-5. Philadelphia: W. B. Saunders Company, 1923.

34 Edward M. Hartwell, "On Physical Training," 1, p. 752, *Report of Commissioner of Education for 1903*, 2 vol. Washington: Government Printing Office, 1905.

35McKenzie, *Exercise in Education and Medicine*, p. 369.

36Fred E. Leonard, "Physical Training in the Colleges," National Education Association *Journal of Proceedings and Addresses*, XXXVI (1897), p. 914.

37Sargent, "The Inomotor," *American Physical Education Review*, V (December, 1900), p. 314.

countries through the YMCA. President Eliot pointed out the broad influence of these physical examinations not only for school children and college students but also for factory employees and Army and Navy recruits.[38]

It is more difficult to assess the value of Dr. Sargent's direct influence in persuading colleges to give credit for required physical education. His efforts in this direction at Harvard were a dismal failure but elsewhere he was more successful, and Harvard made belated amends by requiring freshman physical education without credit in 1919. But Dudley Sargent never ceased to crusade for adequate physical education programs for all college students and he steadily urged the necessity of training the body along with the mind because the two were actually indivisible.

Dr. Sargent did his greatest service perhaps in helping to end the battle of the systems and to promote mutual respect and unity among the physical educators. Boykin's studied opinion in 1892 concerning the detrimental effect of this conflict was: "All the history of the subject [physical education] shows that the conflict of systems and methods, not popular indifference, has been, next to the inefficiency of teachers, the most dangerous enemy with which physical training has had to contend."[39] At both the Harvard Summer School and the Sargent Normal School Dr. Sargent offered a broad curriculum which included German gymnastics, Swedish exercises, games and athletics; all were taught by teachers well versed in their subject. George Brosius, technical director of the North-American Turnbund Normal School at Milwaukee, wrote in 1886, "It is principally due to the efforts of Dr. Sargent that the attention of the public has been called to *Das Deutsche Turnen*."[40] At the Boston Conference, Sargent made an eloquent plea for a balanced physical training program in America, not centered about one system:

> What America most needs is the happy combination which the European nations are trying to effect: the strength-giving qualities of the German gymnasium, the active and energetic properties of the English sports, the grace and suppleness acquired from the French calisthenics, and the beautiful poise and mechanical precision of the Swedish free movements, all regulated, systematized, and adapted to our peculiar needs and institutions.[41]

As president of the national Association in 1894, Sargent expressed the hope that a department for the illustration of floor work would be established to encourage any individual or group to exhibit

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38In the introduction to *Dudley Allen Sargent, Fiftieth Anniversary, 1869-1919*, pp. 6-7. Cambridge: Caustic Claflin Company, c. 1919.

39Boykin, *op. cit.*, p. 524.

40*Proceedings of the American Association for the Advancement of Physical Education*, 2nd Annual Meeting, November 26, 1886, pp. 31-2.

41Isabel C. Barrows, editor, *Physical Training*, p. 76.

their system.[42] He stated that something good formed the basic principles of every system of physical training and the teacher should know enough about all exercises to use them for what they are worth without fear or prejudice. He continued:

> No one, who is not afflicted with the insanity of conceit, can think for a moment that a body of men, who have been working along certain lines of physical training for years, will not have acquired knowledge and experiences that those working along different lines of the same training have missed, though they in turn may have made other discoveries, and acquired other experiences that are equally valuable. . . . It is the realizing sense of the limitations that surround the individual investigator that should make us anxious to compare our ideas and exchange our experiences. In fact, I have always supposed that was the object of an association.[43]

Dr. Sargent could advocate the use of various systems, yet remain aware of their limitations. He praised the Swedish system because it made the most economical use of time and was physiologically effective.[44] However, he also regarded it as laborious because the exercises were not rhythmical and music was not used.[45] Sargent had little regard for the Delsartian system because it did not require the muscular effort which was prerequisite to securing the benefits from muscular exercise.[46] But in spite of his personal antipathy, the Delsarte system was taught at the Summer School and his normal school.

Evidence has already been given to show Dr. Sargent's high regard for sports and games in a physical education program. At first, he considered sports particularly valuable for their disciplinary training—"the undergoing of present hardship for future gain"[47]—but he later recognized the much wider contributions of athletics. In 1910[48] he declared that the conduct of sports and exercises should emphasize their educational and cultural value, and reduce the competitive element. Youth needs to realize that it is possible for one to be a gentleman without being a dude and an athlete without being a "tough." Then sportsmanship will be applied on the field. The pub-

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42*Proceedings of the American Association for the Advancement of Physical Education*, 9th Annual Meeting at Yale Gymnasium, New Haven, Connecticut, April 5, 6, 7, 1894, p. 140.

43*Ibid*, pp. 139-40.

44*Ibid*., p. 138.

45Sargent, "Useful Dancing from the Standpoint of Physical Training," *Mind and Body*, XVL (September, 1909), p. 184.

46*Proceedings of the American Association for the Advancement of Physical Education*, 7th Annual Meeting held in Philadelphia, Pennsylvania, 1892, p. 89.

47Sargent, "The Physical Proportions of the Typical Man," *Athletic Sports*, the Out-of-Door Library. New York: Charles Scribner's Sons, p. 25. 1897.

48Sargent, "Competition and Culture," National Education Association *Journal of Proceedings and Addresses*, IIL (1910), 223-8. This paper was read before the Department of Superintendence of the NEA at Indianapolis in March, 1910, and is the source for the rest of the paragraph.

lic too must realize that college sports are not conducted for mass amusement but are for the training of the sons and daughters of the republic to meet in better fashion the duties of life and the responsibilities of citizenship.

Dr. Sargent's sane philosophy was particularly influential through the Harvard Summer School since over three-fourths of the students were regular teachers during the year in schools, colleges, private gymnasiums, athletic clubs, and the like. The summer school registration totalled 4,469 during Dr. Sargent's tenure and for the entire existence of the school to 1932, there were 7,680 registrations which represented 5,086 individuals.[49] The subtlety of Dr. Sargent's influence upon countless children and students through their teachers was expressed in an informal address by Dr. McKenzie:

> Now to many of us whose lives have been influenced in physical education the Hemenway gymnasium, which is not perhaps quite up to date, has become a kind of shrine because it has stood for a long period of straight, fine, constructive, pioneer work, and Dr. Sargent's intellectual children and grandchildren and all their relations—because there are many here who have been profoundly influenced by his life and work who have never come under his direct supervision or teaching—all of them come back to it at one time or another as to one of the shrines that has witnessed great deeds and devoted service.[50]

Much of the freedom enjoyed by modern women in matters of dress and activity is a result of Dr. Sargent's continual efforts to secure this freedom. The generally conservative attitude of the times is typified in this expression by the principal of a Colorado high school in 1895:

> It may be a little old-fashioned for me to say that, while welcoming women to all professions (and I think they can do work in a great many of them), while rejoicing with them over the gaining of suffrage in this and other states, and while holding that all opportunities of education ought to be open to them that are open to men, I still believe that the spheres of women and of men are not exactly the same; that if they were to fulfill the same functions, Almighty God, in his wisdom, would have found some way of making them the same, and that, if we make, or attempt to make, men out of women, the latter will soon become what they are not now, the weaker sex. I believe that it would be a misfortune, if, by physical or mental education, we should take the femininity out of women, and neglect or extinguish that grandest, most sacred of all instincts, the instinct of motherhood, upon which not only the welfare but the very existence of the nation depends.[51]

At least one woman had to overcome the objections of her family

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[49]Clarence B. Van Wyck, "The Harvard Summer School of Physical Education, 1887-1932," *Research Quarterly*, XIII (December, 1942), p. 426.

[50]"Informal Addresses," *American Physical Education Review*, XXV (October, 1920), p. 316.

[51]Edward F. Hermanns, "Physical Training," National Education Association *Journal of Proceedings and Addresses*, XXXIV (1895), p. 68.

in order to teach coeducational classes at the Harvard Summer School.[52]

Other opposition was expressed by faculty members at Vassar in 1883 who commented on the proposed introduction of the Sargent exercises and divided skirts in shocked tones: "The girls won't stand for it!" "They will never put on divided skirts." "Some of those measurements are actually immoral."[53] The faculty, however, bravely approved the change if it could be done without antagonizing the students. The change was made, not only at Vassar, but at many other schools throughout the country, and another step had been taken toward greater freedom for women.

Sargent demonstrated in a practical manner that women could do gymnastic exercises and indulge in outdoor sports within their physiological limits. This was a fact which attracted many visitors to the summer school and his normal school, and these spectators often expressed their amazement at both the activity and the enthusiasm of the girls. One such visitor, a stately dowager, asked Dr. Sargent whether he wasn't afraid of making the young women masculine and having them lose their feminine charm. His reply was to the point: "Well, it has been my experience in life that it is easier to tame down a wild one than to wake up a dead one."[54]

Dr. Sargent and the Sargent School had an important part in the development of the aesthetic dancing of Melvin Ballou Gilbert which became exceedingly popular in this country up to the early years of the decade, 1930-1940. As related by Carl Schrader,[55] Gilbert had a dancing school in Portland, Maine, and met Dr. Sargent in 1892 through Francis Dohs, a teacher in the Harvard Summer School. Sargent told Gilbert that from the physical educator's point of view, dancing was weak because it involved only the legs and not the trunk and arms. Upon this suggestion Gilbert built an entire structure of what became known as the aesthetic or classic dancing. The Gilbert dancing was a modified ballet which omitted toe dancing and the more intricate movements but exercised the body and arms as well as the legs.[56] This new dance was first taught

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52Letter to author from Miss Jennie B. Wilson, May 8, 1947.

53Recalled by Dr. Eliza Mosher in "Informal Addresses," *American Physical Education Review*, XXV (October, 1920), p. 311.

54Letter from Carl L. Schrader to Miss Brenda Boynton, June 30, 1942 (Sargent College). Schrader formerly taught at both the Sargent School and the Harvard Summer School.

55"Our Tribute to the Late Mr. Gilbert," *Mind and Body*, XVII (June, 1910), p. 142. The writer of the article is identified only by the initials CLS, but he must be Carl L. Schrader, a member of the editorial committee.

56The author is indebted to Miss Elizabeth Andrews, former dancing instructor at the Sargent School and now librarian, for this description of the Gilbert dancing.

by Mr. Gilbert at the Harvard Summer School in 1894 and in the fall he became an instructor at the Sargent School where he remained until his death in 1910.

The opening of the Sargent summer camp at Peterboro, N. H., was a recognition both of the value of camping as an educational activity and of the importance of outdoor sports. Modern physical education stresses individual needs—a fact which Sargent was among the first to observe in the application of his prinicples. The following entry in the *Sargent School Catalog* for 1902-03 is pertinent:

> No rigid system is adhered to. In the opinion of the director the *condition* of the *individual* as determined by *age, sex, race, environment,* etc., should determine the *time, nature,* and *amount* of physical training necessary in order to attain the best results.[57]

The decisive dominance of the Sargent School in physical education teacher training is lucidly shown in a study made by Berry in 1920.[58] He secured information from twenty-eight colleges, YMCA schools, and private institutions which gave professional training in physical education. Results showed that a total of 9,656 individuals were graduated from these schools. The Sargent School graduated 3,008, or nearly one-third of the total number of graduates from all the schools. Springfield College had the next highest number of graduates, 885. That is, in 1920, one out of every three graduates of a teacher-training program in physical education was a Sargent School graduate; one out of every eleven was a graduate of the next largest school. The enrollment at the Sargent School in 1920 was 470, almost twice that of the Savage School in New York City which was next with 242 students. Today, offering a four-year course as part of Boston University, Sargent College has a capacity enrollment of 500 students.

Less evidence is available to show the more personal nature of Dr. Sargent's influence with students and friends. He helped his graduates find positions (which was good business) and seemed to have an interest in each student. His friendship with other leaders in the profession bore direct fruits which benefited all the members. For example, R. Tait McKenzie first attended the Harvard Summer School in 1890 and there "he received the impulse that developed his love for beauty of form as manifested in a perfectly healthy and well developed human being."[59] McKenzie himself acknowledged his debt to Sargent who had first interested

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57P. 5.

58Elmer Berry, "Problems in the Recruiting of Teachers in Physical Education," *American Physical Education Review,* XXV (June, 1920), 233-9.

59"News Notes," *American Physical Education Review,* XVII (October, 1912, 560.

him in putting the athletic types into tangible form through sculpture.[60] McKenzie's interest led to the sculpturing of the statue of the typical college athlete based on measurements of four hundred leading strength-test performers made by Sargent at Harvard.[61] Many other excellent statues, plaques, and medallions by McKenzie demonstrate his interest in the human body and his deftness and beauty of expression.

Dr. Edward Mussey Hartwell first met Dr. Sargent on a visit to Hemenway Gymnasium in 1881. The following year he accepted a position in the new gymnasium at Johns Hopkins and introduced the Sargent examinations, apparatus, and exercises.[62] It seems quite likely that Dr. Sargent assisted Hartwell in the writing of his famous report for the Commissioner of Education in 1885.[63] At the time he was preparing the report, Hartwell wrote to Sargent asking him for information and said, "When I get the thing in proof, I shall submit it to you for suggestions and criticisms."[64] Hartwell later became director of physical training for the Boston school system.

Luther Halsey Gulick, who did such magnificent work for physical training in the Young Men's Christian Association and later in the New York public school system, was inspired by Blaikie's book, *How to Get Strong and Stay So,* which he read while a student at Oberlin College. He left Oberlin to attend the Sargent Normal School in 1886 and then entered YMCA work.[65] Gulick had an important part in getting the International YMCA to use the Sargent measurements as a basis for their physical examinations, although the Association then adopted a short form after two years. Dr. James H. McCurdy was another prominent YMCA leader who lectured at the Summer School for a number of years.

Dr. Sargent's courageous action in regulating athletic events at Harvard caused him untold personal embarrassment and antipathy, but he never sacrificed his principles for personal convenience and continued his fervent opposition to everything that he thought was detrimental to college athletics. College teams do not

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60"Informal Addresses," *American Physical Education Review,* XXV (October, 1920), 315.

61R. Tait McKenzie, *Exercise in Education and Medicine,* p. 272.

62Fred E. Leonard, *Pioneers of Modern Physical Training,* p. 151. New York: The Association Press, 1919.

63*Physical Training in American College and Universities.* Bureau of Education Circular of Information No. 5, 1885. Washington: Government Printing Office, 1886.

64Hartwell to Sargent, March 23, 1884 (Harvard Archives).

65Ethel J. Dorgan, *Luther Halsey Gulick, 1865-1918,* p. 6. Teachers College, Columbia University, Contributions to Education, No. 635. New York: Bureau of Publications, Columbia University, 1934.

today play professional clubs; trainers and coaches are hired by the college; graduates are not eligible for varsity teams; athletes are examined before competition; athletics are supervised by some form of a faculty-alumni-student committee. All these practices are so well established today that it seems almost incredible that they should ever have been questioned and bitterly opposed.

As a medical examiner for Harvard athletes, Sargent accepted a heavy responsibility in certifying men for competition. He recommended that athletes observe the following precautions to reduce the risks from athletics to a minimum:

1. Be examined by a reputable physician and present a *written* opinion.

2. Understand that it is not desirable to engage in violent exercise until eighteen or twenty because the heart and lungs are not fully developed until then.

3. Avoid tight clothing which strains the heart.

4. See that the blood is circulated and warm before severe exertion.

5. Eat a light meal no sooner than three hours before a contest.

6. Do not take a cold shower after vigorous exercise.

7. Make careful preparation and training to attain condition.[66] These rules are sensible guides for athletes today.

The influence of Dr. Sargent in the field of testing is still important. His first strength test is no longer used with his computations. However all the parts have been taken for the strength test devised by Frederick R. Rogers who says that his interest in testing had its inception in 1911 when he took the Harvard Strength Test as a student at Phillips Exeter Academy.[67] Rogers tests lung capacity, right and left hand-grip, back lift, leg lift, push-ups, and pull-ups. However, he uses a different computation for the results than Sargent and determines a Strength Index and a Physical Fitness Index which are his own contributions.[68] The Rogers test is probably the most widely used of the strength tests today.

The Universal Test for Strength, Speed, and Endurance was never widely used but it was a forerunner of other tests of speed and endurance as distinguished from strength, and thus a better measure of athletic performance. The Pep test, or Sargent Jump,

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[66]Sargent, "College Athletics and Heart Disease," *Educational Review*, II (December, 1891), pp. 462-5.

[67]Frederick Rand Rogers, *Physical Capacity Tests in the Administration of Physical Education*, p. iv. Teachers College, Columbia University, Contributions to Education, No. 173. New York: Teachers College, Columbia University, 1925.

[68]*Ibid.*, p. 50.

today remains the best test available for predicting explosive energy or power.

The practical and utilitarian construction of modern gymnastic apparatus and equipment is also a result of Dr. Sargent's mechanical ability and professional experience. Some of the deficiencies of the old-style apparatus were described by Sargent who complained that gymnasiums were built by architects who did not know what was needed, and that carpenters built apparatus for appearance rather than use.[69] Hanging ropes were made of hemp and stiffly tarred to make them durable. With wry humor, Sargent observed, "This object is effected for it is never used twice by the same person."[70] The sand-bag weighed seventy-five pounds with heavy canvas which caused skinned knuckles. Mats weighed four hundred pounds and were filled with excelsior or corn-husks. These soon became matted and lumpy and caused sprained ankles. The pulley-weights banged, rattled, and erupted dirt and sawdust when they hit the trough. Parallel bars were broad at the base and narrow at the top, leading to insecure grip. The wood also splintered to add to the inconvenience and danger. Trapeze bars were two inches in diameter and poorly hung. The rungs of horizontal ladders were rough and raised blisters.

Sargent's keen attention to detail led him to correct many of these conditions in the Hemenway Gymnasium. Hand ropes were made of cotton and side rings were covered with rubber. Horizontal bars were centered with steel rods and thus were thinner and easier to grasp. Spring boards could be placed in sockets to prevent sliding. Parallel bars were shaped to the hand and bar rungs were smoothed.[71]

The old-style gymnasts took a kind of savage pride in the skinned hands and bruises they endured in acquiring their skill, and Dr. Sargent himself said that he was glad he went through the experience. But he was intelligent and practical enough to realize that these unnecessary conditions kept many people out of the gymnasium and were particularly discouraging to beginners. He therefore made needed improvements in mechanical construction and thereby contributed to the functional gymnasiums we have today.

Sargent was often consulted on problems of gymnasium construction. Together with Frederick Law Olmstead, the famous landscape architect, Sargent planned and established the out-

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69Sargent, "Physical Education in Colleges," *North American Review*, CXXXVI (February, 1883), pp. 166-80. This is the source for the rest of the paragraph.

70*Ibid.*, p. 174.

71Sargent, "The Apparatus of Hemenway Gymnasium," *Harvard Register*, I (February, 1880), 44-5.

door gymnasium at Charlesbank in Boston in the late 1880's.[72] Dartmouth College acknowledged Sargent's advice and suggestions for the remodelling of their gymnasium and the conduct of physical training and athletics.[73] The Narragansett Company sent blueprints of the gymnasium at Rensselaer Polytechnical School at Troy, New York, to Sargent for his recommendations.[74]

SUMMARY

All available material clearly shows that the life and work of Dudley Allen Sargent justified the evaluations quoted at the beginning of this paper. Sargent's professional approach helped greatly to raise the subject of physical education to a level of comparative respectability in the college curriculum. The wide-spread use of his apparatus and principles, the adoption of his methods of testing and measuring, his direct influence on men and women teachers through his own normal school and the Harvard Summer School, his active and vigorous professional service, his numerous articles and addresses—all contributed to make Dudley Sargent the leading physical educator of his time. Instead of taking sides in the battle of the systems and thereby hindering the development of the profession of physical education, Sargent wisely stressed the merit and benefits of all systems. He stood for sane control of intercollegiate athletics when such a stand was unpopular. He did much to revive the "fainting female" and induce her to enjoy the benefits of vigorous activity. His active and creative mind devised apparatus, invented new games, and originated tests of strength, endurance, and power. In brief, the touch of his guiding hand was felt in all phases of school physical education—teacher training, athletics, curriculum, tests and measurements, gymnasium and apparatus construction—and, motivated by a sense of broader responsibility, he endeavored to popularize physical exercise and hygienic living for the great mass of Americans.

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[72] Samuel A. Eliot, editor-in-chief, *Biographical History of Massachusetts: Biographies and Autobiographies of the Leading Men in the State,* 3 vol. Boston: Massachusetts Biographical Society, 1909. See under D. A. Sargent, volume II; pages are not numbered.

[73] *Report of the Advisory Committee to the Executive Committee of the Dartmouth College Alumni Association Concerning the Improvement of the Gymnasium and the Securing of an Athletic Field,* p. 13. Cambridge: John Wilson and Son, 1892.

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The Establishment of Principles Which Are Essential for the Realization of the Objectives of Physical Education

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THE PROBLEM

THE purpose of this study is to conduct a survey of the objectives of physical education; to attempt to synthesize the modern objectives of physical education; to reduce the objectives to a common denominator in terms of both physical education and the sciences of biology, psychology, and sociology; to establish a representative statement of the modern objectives of physical education; to derive and validate general principles that are basic to the sciences and are related to the representative statement of the modern objectives; to make implications of the general principles in relation to the program of physical education. These implications become specific principles that represent guiding rules in the methodology of physical education.

With the establishment of a representative statement of the objectives, and with the application of scientifically derived principles that should lead to the effective realization of the objectives, physical education should take its place as a constructive educational agency. This paper is intended to contribute toward that end.

I. Survey of Objectives

A. In this systematic analysis, the study was divided into three divisions: prior to 1900; 1900 to 1920; 1920 to 1935. Objectives were classified under the same headings according to frequency of mention.

B. Effective integration of the developing individual in matters of health, recreation, character, and citizenship was established as a representative statement of the modern objectives of physical education because:

1. Four authorities in the fields of biology, physiology, psychology, and sociology indicated that adjustment of the unified

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An abstract of a thesis submitted in partial fulfillment of the requirement for the degree of doctor of philosophy in the School of Education, New York University, 1946.

organism is of utmost importance in each science.

2. The viewpoints of authorities in the field of physical education could be reduced to a common denominator of integrated adjustment of the developing individual.

3. The socio-educational point of view with emphasis upon citizenship, character, leadership, and social standards became obvious after 1920.

4. The same objectives, health, recreation, citizenship, and character, held leading positions from 1920 to 1935.

C. Effective integration refers to the ability of the individual to adjust himself satisfactorily (according to social standards) to any situation that may arise.

II. Derivation and Validation of General Principles

A. General principles or hypotheses were established which must be recognized in effective methodology if the objectives are to be realized.

1. Twelve scientists (three from each science) recommended authoritative books in the sciences of biology, physiology, psychology, and sociology. Evidence was drawn from these books for substantiation of the priniciples.

2. In the derivation and validation of the principles a representative from each of the sciences worked closely on the study to insure an accurate interpretation of the four sciences as they relate to the objectives and to each other. The principles were corrected continuously until full approval was given by each of the scientists.

3. The genetic viewpoint is expressed herein. The physiological, psychological, and social functions that make up the pattern of growth and development of the individual are continually developing together and actually are inseparable. For purposes of study, however, these functions were treated separately. Hence, if certain factors appeared to have enough status and a significance of their own within the total pattern, they were taken from the total pattern and accorded separate treatment. The separate factors then were recognized as general principles. Even though there was an overlapping of general principles, each seemed to offset the total growth pattern sufficiently to warrant separate discussion. These became the general principles that were validated by the scientists in biology, physiology, psychology, and sociology.

B. Implications were made from the general principles in relationship to the objectives of physical education.

C. General principles and implications to physical education: the endeavor is herein made to present a broad positive statement which combines each of the validated general principles with its implication to physical education.

1. *Reciprocal relationship between hereditary constitution and the conditions under which development occurs.*—The individual must be recognized as a continuously developing (not a developed) organism which represents the joint product of hereditary constitution (maturation) and the conditions under which development occurs (learning).

a. Physical education should recognize the continuously developing individual as a psychogenetic unit whose conduct results from the interaction of his heredity and his total environment (past and present, direct and indirect). The endeavor should be made to contribute toward the effective integration of the developing individual. The leader should plan his methodology in reference to the close relationships between the maturation of the developing individual and his learning in the social context.

2. *Favorable conditions needed for effective integration of the developing individual.*—Favorable conditions ought to be provided during the whole course of growth and development, biological, physiological, psychological, and social, of the individual so that favorable integration may result in effective personal and social adjustment. There should be no hindrance to maturation and learning. The nature and needs of the developing individual should be kept in view always.

a. In *physical education,* wholesome, wisely guided big-muscle play activity may contribute to the effective integration of the developing individual in regard to the physiological and psychological processes.

(1) Activities (organized and administered according to social and moral standards) may provide favorable conditions for achievement of the developmental intermediate objectives:

(a) The development of organic power.
(b) The development of neuro-muscular control.
(c) Emotional development.
(d) Interpretative development.

3. *Individual variation and similarity.*—The wide range of variation in human development demands that respect for individuality should be shown insofar as that is possible:

a. In physical education:

(1) The physiological, mental, social, moral, and even spiritual needs of the whole organism should be taken into consideration.

(2) Individuals should be classified in terms of their immediate diverse individual needs and capacities.

(3) The individual rather than the activity should be the focal point of attention.

(4) The program of the atypical individual should be made as enjoyable as possible.

4. *Physiological and psychological maturation.*—Growth and development take place according to a definite and continuous pattern which depends upon hereditary and environmental factors. Maturation and learning are interrelated.

a. Physical education should be concerned with the immediate needs, capacities, and interests of the developing individual.

(1) The individual should participate in activities of a suitable kind and degree in accord with the stage of development that he has attained and in terms of his physiological condition.

(2) Physical education should adapt its program and teaching methods to the changing biological, physiological, psychological, and social needs of the developing individual.

(3) If the desired outcomes of physical education are to be effectively attained, research is needed in order to ascertain:

(a) When the developing individual is ready to assimilate certain skills, attitudes, and ideals in respect to his maturation.

(b) The optimum degree of exercise that may be beneficial to the relatively normal individual at all ages throughout the entire course of his development.

(c) How much big-muscle play activity is required throughout the course of individual development in order to satisfy growth needs for both sexes at all ages, chronological, physiological, and mental; sex differences should also be recognized.

(d) Evaluation of activities in terms of their energy requirements.

(e) The capacities, needs, and interests of each individual throughout the course of development.

(f) Individual physical potentialities.

(g) The type of activities needed at all stages of development, physiological and psychological, for both sexes.

(h) The equipment best suited to the growing individual; to girls.

5. *Progressive differentiation and specialization from generalized beginnings.*—In both physiological and psychological growth and development there is evidence of progressive differentiation of complex and specialized structures and functions from relatively generalized beginnings. Specialization is made at the sacrifice of

generalization. Specialization which decreases flexibility of adjustment should be avoided.

a. The physical education program should be planned so that the developing individual may participate until adolescence in a broad and general program rather than in a specialized program.

(1) The activities should be arranged progressively from general to specific activity and from the simple to the complex.

(a) The activities should be presented in relation to the degree of neuromuscular, emotional, and intellectual development; interests; physiological condition; and sex of developing individual at the particular time under consideration.

(b) Overspecialization in specialized skills reduces the range of effective physical education of the developing individual.

(c) A generalized background of knowledge, skills, interests, attitudes, and appreciations should enable the individual to become progressively more flexible and adaptive to new situations and should aid in the maintenance of an integrated personality.

(d) Since modern living demands such specialization it is essential that the recreative life be generalized.

6. *Adaptability of the organism to itself, to objects and events and to other people.*—The position is taken herein that satisfactory adaptability should go hand in hand with effective integration, the desired outcome. Satisfactory adaptability should result from the attainment of physiological, mental, emotional, and social maturity. The organism should be maintained adequately at all age levels at all times; economical methods of learning should be employed; adequate controls of conduct should be acquired, including habits, skills, knowledge, attitudes, interests, ideals, and appreciations; problem solving should be encouraged and a desire for self-responsibility should be fostered.

a. Physical education should be responsible within the program for the controlled adjustment of the developing individual.

(1) The developmental objectives of physical education, namely, organic power, neuromuscular control, emotional development, and interpretative development, enable the individual to make more effective adjustment. The objectives demand that activities be conducted according to social standards and under wise leadership if effective adjustment is to accrue.

(2) The program should be adapted to physiological, mental, emotional, and social needs.

7. *Effective integration of the developing individual.*—Desirable integration ought to be the focal point of education. Both physiological and psychological integration depend upon the "structufunctional" relationship. At all times the individual should be considered as a functional whole.

Effective integration of the physiological and psychological processes should enable the individual to function healthfully and free from strain, anxiety, worry, and infection, and in such a way that he may serve society well.

a. Effective integration of the physiological processes:

(1) Progressive integration should exist between all of the systems of the body, from fertilization until death, if a condition of health is to be maintained.

(2) Health is a changing condition in which the developing individual makes effective physiological and psychological adaptation to his constantly changing internal and external environment. Health, therefore, should be considered in terms of both the prevailing conditions and the quality of integrated structure and function of all the parts of the whole at all ages of development. Health for one individual at a given age may not be health for the same individual at a different age because the growth pattern, including the structure and the function of the organism, is constantly changing.

(3) Physical education should be concerned with the development of the integrated personality, which implies total health of the individual; i.e., physical, mental, moral, and social. Physical education ought to be more interested in promoting and maintaining the ideal of the integrated personality who utilizes health as a means to more efficient conduct and social service rather than treating health as an end in itself and therefore emphasizing the postural, therapeutic, and corrective value of exercise.

(a) Physical education is concerned with teaching practices in health, wise use of leisure time, citizenship, and character for the effective integration of the developing individual through the agency of big-muscle play activities.

(b) The main task in physical education is to guide healthy individuals toward effective integration through participation in wholesome big-muscle play activities.

(c) The activities should appeal to the immediate interests and desires of the individual. The leader should superimpose standards upon wants. Such activities may be regarded as the immediate objectives.

(d) Such anticipated outcomes (skills, knowledge, attitudes, appreciations, ideals), related to organic power, neuromuscular, emotional, and interpretative development may be regarded as the intermediate developmental objectives of the teacher. Through interesting activities adapted to his needs then the individual will acquire desirable controls over conduct.

(e) The rhythmical demand for rest should be given full consideration.

(f) The establishment of attitudes toward lifetime recreational pursuits with a view to maintaining strength and endurance is a responsibility of physical education.

b. Effective integration of the psychological processes:

(1) The organism acts as an organized whole not as a body and mind. Integration occurs at all levels; i.e., perception, attention, and learning. If the individual is to make adjustment to himself, to objects and events, and to other people, the psychological operations should be effectively integrated progressively throughout his lifetime. Psychological operations include habits, skills, postures, perceptual functions, attention and interest, emotionalized action, motives, problem-solving, personality or character.

(2) Physical education should attempt to obtain effective integration of the psychological processes by participation in wisely directed, well chosen activities, which are engaged in according to hygienic, social, and moral standards. The selected activities should fit into the social pattern of the individual so that the psychological operations may be given social expression.

(a) Physical education should direct learning so that improved conduct may contribute to personal and social adjustment. Control objectives and anticipated outcomes will aid in his planning.

8. *The role of motivation in conduct.*—The selection of an appropriate stimulus situation should be made in terms of wants or desires if the response pattern is to be controlled or directed. Such motivation will apply to the developmental pattern of all of the psychological operations. Stimuli should be selected for the developing individual so that he may be ever eager to improve himself. In order to fit into the social contact, social standards should be superimposed upon personal wants. Self-expression should be encouraged through participation in interesting and challenging activities. Obstacles should be arranged that are progressively difficult and which, when overcome, will afford satisfaction.

a. In physical education motives should be utilized which will prove effective in realizing the objectives. The individual should be guided to effective integration through appealing and interesting activities.

(1) A varied program should be offered so that everybody may gain a measure of success in some activity for personal satisfaction and social approval.

(2) The interests, wants, or desires of the individual should be the foundation upon which the program should be based. Physical education should endeavor to steer such wants into channels favorable to the person and acceptable to society.

(3) Self-expression may be encouraged through participation in interesting and challenging activities. Obstacles should be arranged that are progressively difficult and which, when overcome, will afford satisfaction. Such effort leads toward self-discipline and effective adjustment. The individual should receive much encouragement; too many disappointments should be avoided. Self-confidence should be the outcome.

9. *Learning and teaching.*—Learning depends upon present conditions and previous experience of the whole organism. Previous experience affects the response of the developing individual. Control of the stimuli may change the response. Habits, skills, knowledge, attitudes, and appreciations should be acquired that will lead toward improvement of conduct and adequate personal and social adjustment. The individual learns by doing. His growth and development occur through self-activity.

a. In physical education learning activities should be planned:

(1) The leader should endeavor to make the developing individual as adaptable and as flexible as possible from the standpoint of skills.

(2) The learner may treat the skills as ends in themselves but the teachers should utilize them as means to other ends.

(3) The best type of instruction provides conditions in which the individual will be motivated to develop himself to full potentiality. Interest should be the focal point of instruction.

10. *The school as a social agency for effective social adjustment (socialization) of the individual.*—The individual and society should be considered together; one cannot exist without the other. The school is one means of promoting social relationship; students should learn to make adequate adjustment to each other and to all the social situations involved in their life together. The various psychological operations should become progressively social in character from childhood to adulthood. Habits, skills, knowledge, emotionalized actions, problem solving, and character traits should take on social meaning. In progressive socialization individual initiative and responsibility should be encouraged.

a. The objectives of physical education should be social in character. The attempt should be made to gain controls of conduct in the individual which will enable him to become effectively socialized.

11. *Competition and co-operation.*—Education should recognize competition as one of the outstanding characteristics of life. Co-operation is just as important as competition in the social process.

a. In physical education those factors of competition should

be encouraged that lead toward the attainment of the objectives. Cooperation should be attained through cooperation. Therefore it is essential that competition and cooperation be considered in terms of needs, capacities, and interests.

12. *Freedom and discipline.*—An environment including both freedom and discipline should be provided continuously for the individual if he is to make effective social adjustment. Under wise leadership, self-discipline should be encouraged by participation in activities that are both difficult and interesting, and that require personal effort. The activity should challenge the individual to discipline himself to overcome the difficulty.

a. Physical education offers excellent opportunities for effective training in manners and morals if the leaders use the activities as a means to an end rather than as ends in themselves. The program should be centered around activities in which self-discipline may be developed.

(1) Physical education should strive to gain self-direction in the individual according to social, moral, and hygienic standards. The important feature of an activity is wholesome interest and effort. Then it is possible to superimpose standards upon his wants.

13. *Leadership and "followership."*—Leadership and "followership" are two closely related features of the social process in democratic, cooperative society. A competent leader should know the worth of cooperative society. A competent leader should know the worth of cooperative followership by actual experience.

a. In physical education a stimulating atmosphere of learning should be promoted so that the developing individual may lead and be led to best advantage.

(1) Athletics are admirably suited for progressive leadership.

14. *Moderation.*—Society should strive to provide conditions in which moderation becomes a guiding rule of conduct throughout life.

a. In physical education and athletics moderation is desirable. The aesthetic, social, moral and even spiritual values of sport should be striven for. Other values should not be sacrificed for the sake of winning.

The preceding principles together with their implications for the teaching situation should become rules of procedure if the objectives of physical education are to be realized effectively. Ideally then, physical education should endeavor to contribute to the effective integration and to the joyous development of the individual physically, mentally, morally, and socially, through the agency of big-muscle play activities that are presented according to the needs, capacities,

and interests of the developing individual, and in a genetic sequence so that the problem-solving patterns of conduct on the one hand, and the development of a self-disciplined, integrated personality on the other hand, may become effective in a forward-moving social setting.

III. Specific Principles

These were deduced from the implications to physical education in terms of methodology. This was done by treating the factors of a teaching situation: the learner, the conditions in the physical education environment applicable to the principle, the activities, the leader, and the standards. These specific principles then become guiding rules of action for effective methodology. This procedure in reference to the general principle of adaptability is presented here as an example:

A. The learner:

1. Individual welfare of each student physically, emotionally, mentally, and socially should be the sole consideration.

B. Conditions in the physical education environment for desirable adaptation:

1. The environment should be controlled so that adaptations are of benefit. Physical, mental, emotional, and social development should be encouraged.

a. Organic health:

(1) Conditions should be so regulated that the individual keeps within his physiological bounds.

b. Neuromuscular control:

(1) Specialization should not occur too early or flexibility of adjustment may be reduced.

c. Emotional and interpretative development:

(1) Situations should be provided that require personal and social adjustment.

C. Activities:

1. Activities should be adapted to needs, capacities, and interests. A variety rather than just a few should be offered.

2. Participation in coeducational recreational activities should be encouraged for better adjustment to the opposite sex.

D. The leader:

1. Leaders need to be adjusted physically, emotionally, mentally, morally, and socially. Example is a potent factor in teaching.

E. Standards:

1. The individual should adjust to accepted social standards.

The Effects of Physiological Age on Motor Achievement

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(Submitted for publication, February, 1948)

STATEMENT OF THE PROBLEM

WHILE it can be clearly pointed out with mathematical certainty that boys increase in strength, size, and power as they grow older, the question has been raised as to what effect, if any, the various cycles of maturity, pre-pubescent, pubescent and post-pubescent, have upon a boy's endurance and ability to perform motor skills. It is the purpose of this study to investigate this question.

REVIEW OF LITERATURE

Crampton (1) in 1908 stated that adolescence extends from puberty to maturity. Its normal range varies from ages fourteen to twenty-five in the male, and from twelve to twenty-one in the female. Crampton also states that "all pubescence groups contain a mixed population and that we are unable to proclaim from the mere fact of age from twelve to fourteen that any individual is immature, maturing, mature; when he will mature, or how long he has been mature" and concluded that designations of sexual characteristics based upon age alone are incomplete and misleading.

Dimock (2) states that the reasons for some boys having a physiological or pubescent development at twelve that is more advanced than that of boys at sixteen, may be due to such factors as race, intelligence, nationality, socio-economic status, climate, immediate family heredity, physical stature, hygienic conditions, and glandular functioning. He also declares that rapidity of growth is associated with pubescent development. We cannot assume the presence of puberty nor predict physical growth accurately from chronological age alone. The most marked differences in height and weight of boys, in various stages of pubescent growth, are found in the fourteen- and fifteen-year-old groups. This indicates that the period of most rapid growth in height and weight comes in the year during which a boy passes from pubescence to post-pubescence.

A thesis submitted in partial fulfillment of the requirements for the degree of master of arts, State University of Iowa, Iowa City, Iowa.

Dimock also states that physical strength, as measured by Rogers' Test, increases rapidly throughout the adolescent years, and virtually doubles in the age period from twelve to sixteen years. He states that motor ability, as measured by the Brace Test, does not increase with age as rapidly as does physical capacity and strength. Pubescent and post-pubescent boys have a lower motor ability score at every age level than has the pre-pubescent boy. On the average, boys who grow most rapidly in height and weight, gain as much, measured by the Brace Test for motor ability, as do those of lesser growth in height and weight.

Keithly (3) concludes that the increase in strength of boys during the adolescent period is greater than that which might be expected, considering the increase in chronological age and size alone. He explains that this increase may be attributed to some factor of maturation.

PROCEDURE

Two hundred and thirty-five boys in the Merrill Junior High School in Oshkosh, Wisconsin, were examined and classified as pre-pubescent, pubescent, and post-pubescent by using Crampton's criteria (1). Thirty-five of these were expected to graduate to the senior high school at the end of the first semester and were therefore eliminated from the study. Fifty boys were chosen for each of the pre-pubescent, pubescent, and post-pubescent groups. These were selected at random from the remaining two hundred eligible boys.

Criteria for Classifying

Pre-pubescence is that total period of life before which there are physiological signs of puberty. The beginning of pubescence is commonly marked by pigmented hairs in the pubic region. Post-pubescence is marked by a kink or twist in the pubic hair and a wrinkled scrotum.

Measurements

The subjects' heights were measured to the nearest quarter of an inch and their ages to the nearest month. Each boy's classification index was computed by McCloy's formula (4).*

The McCloy Strength Index

The McCloy strength index (4) was applied to data secured by testing each subject twice. A time lapse of two weeks was allowed between the first and second tests. The best scores of the two measurements were used.

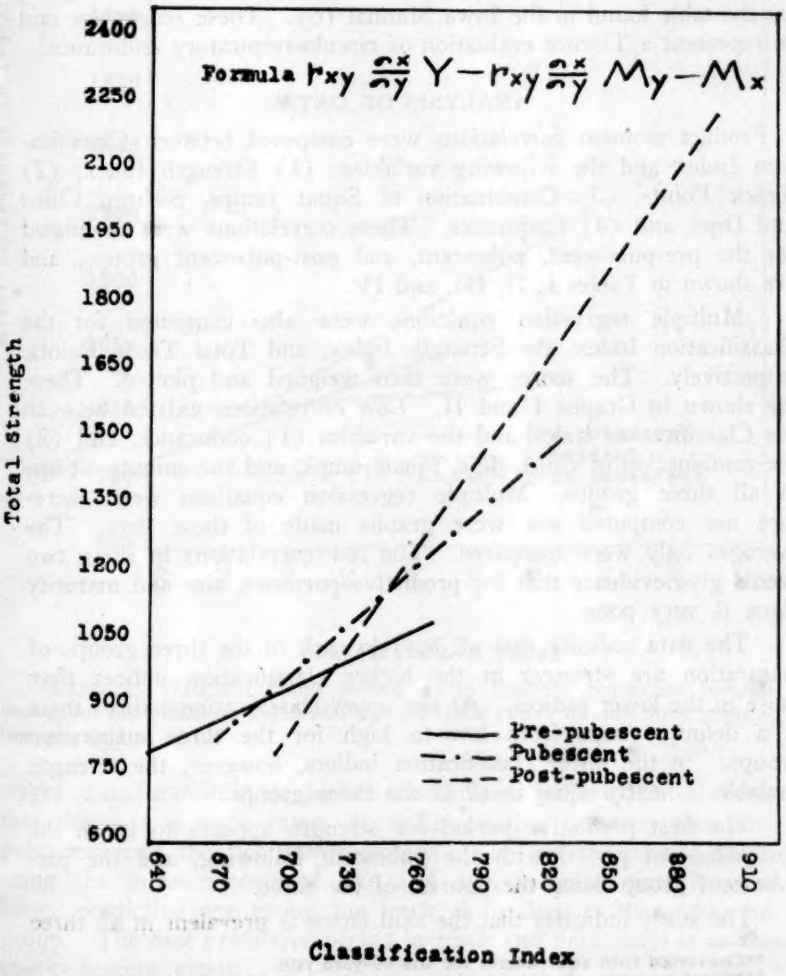
*20 (age) + 6 (height in inches) + (weight).

General Motor Capacity Tests

The General Motor Capacity tests were used to determine the Motor Quotient of the pre-pubescent, pubescent, and post-pubescent groups in order to determine the average Motor Quotient. The subjects were required to practice the Burpee and the Sargent Jump. McCloy's scoring tables (4) were used on these test data.

Track and Field Tests

The results from track and field events, consisting of the six-



Graph I. Weighted scores plotted as to multiple regression formula shown, for Classification Index and Strength for the three maturation groups.

second dash, ** the two-hundred yard run, the standing broad jump, the eight-pound shot-put and the high jump, were scored by the McCloy scoring tables (5). The total number of points made by each boy was computed and recorded.

Data, secured through a battery of tests which consisted of squat jumps, two-minute sit-ups, push-ups, and chins were combined according to another formula submitted to the author by McCloy.***

Endurance was determined by using the scores from the 200-yard run and the six-second dash. These scores were converted by the table found in the Iowa Manual (6). These scores are said to represent a T-score evaluation of circulo-respiratory endurance.

ANALYSIS OF DATA

Product moment correlations were computed between Classification Index and the following variables: (1) Strength Index, (2) Track Points, (3) Combination of Squat Jumps, Sit-ups, Chins and Dips, and (4) Endurance. These correlations were calculated for the pre-pubescent, pubescent, and post-pubescent groups, and are shown in Tables I, II, III, and IV.

Multiple regression equations were also computed for the Classification Index, the Strength Index, and Total Track Points, respectively. The scores were then weighed and plotted. These are shown in Graphs I and II. Low correlations existed between the Classification Index and the variables (1) endurance, and (2) the combination of chins, dips, squat jumps, and two-minute sit-ups in all three groups. Multiple regression equations were therefore not computed nor were graphs made of these data. The averages only were compared. The low correlations in these two events give evidence that for predictive purposes, size and maturity alone is very poor.

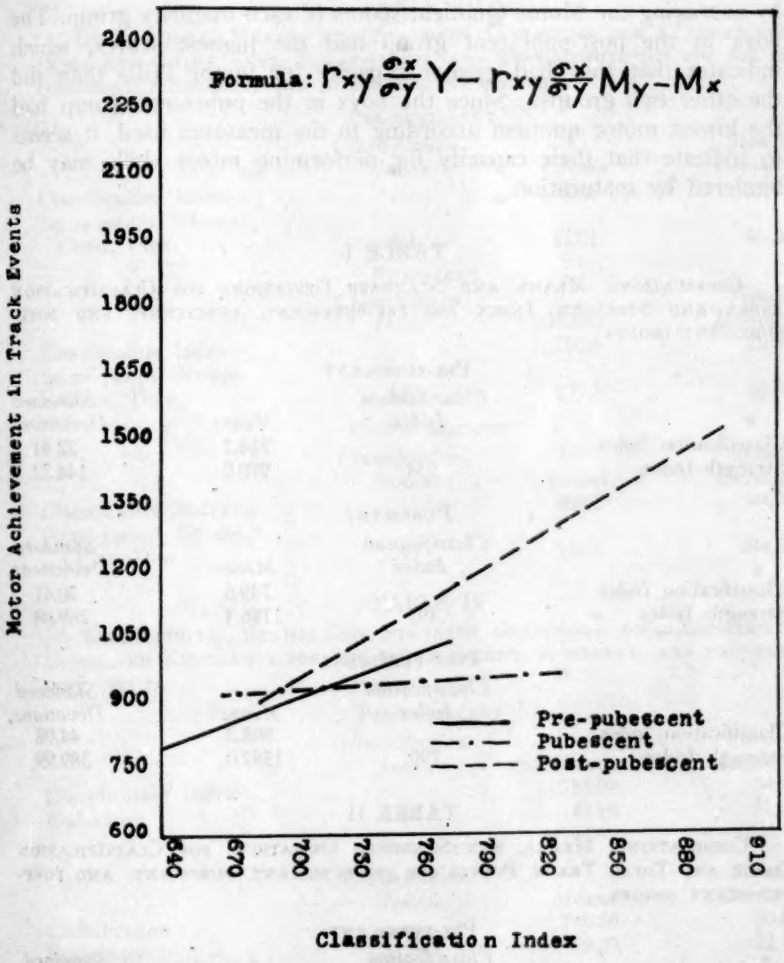
The data indicate that all boys in each of the three groups of maturation are stronger in the higher classification indices than those in the lower indices. At the upper classification indices there is a definite range from low to high for the three maturation groups. In the lower classification indices, however, the strength variable is nearly equal in all of the three groups.

The best predictive period for strength appears to be in the post-pubescent period with the pubescent following, and the pre-pubescent group being the poorest of the three.

The study indicates that the skill factor is prevalent in all three

**Converted into equivalents for the 60-yard run.

***Total number of sit-ups plus one and one-half times the number of squat jumps plus one and one-half times the number of push-ups plus five times the number of chins.



GRAPH II. Weighted scores plotted as to multiple regression formula shown, for Classification Index and selected track events for the three maturation groups.

stages of maturation in the higher classification indices. It also shows that there is a wide range of skills existing between the post-pubescent and the two lower groups. The pre-pubescent group, using the measurements of size and age, indicates that it is a better predictive age group for track skills than is the pubescent group. The best predictive period in track and field skills is in the post-pubescent group.

The respective motor quotient scores of 101.14, 98.84, and 96.48 for post-pubescent, pre-pubescent, and pubescent were found

by averaging the Motor Quotient scores of each maturity group. The boys in the post-pubescent group had the highest scores, which indicates that they had greater capacity for motor skills than did the other two groups. Since the boys in the pubescent group had the lowest motor quotient according to the measures used, it seems to indicate that their capacity for performing motor skills may be hindered by maturation.

TABLE I

CORRELATIONS, MEANS, AND STANDARD DEVIATIONS FOR CLASSIFICATION INDEX AND STRENGTH INDEX FOR PRE-PUBESCENT, PUBESCENT, AND POST-PUBESCENT GROUPS

	PRE-PUBESCENT		
	Classification Index	*Means*	*Standard Deviations*
Classification Index	.....	714.2	32.41
Strength Index	.534	970.0	144.22
	PUBESCENT		
	Classification Index	*Means*	*Standard Deviations*
Classification Index	.....	749.6	30.41
Strength Index	.495	1186.4	269.68
	POST-PUBESCENT		
	Classification Index	*Means*	*Standard Devotions*
Classification Index	.....	803.2	44.08
Strength Index	.790	1582.0	389.99

TABLE II

CORRELATIONS, MEANS, AND STANDARD DEVIATIONS FOR CLASSIFICATION INDEX AND TOTAL TRACK POINTS FOR PRE-PUBESCENT, PUBESCENT, AND POST-PUBESCENT GROUPS

	PRE-PUBESCENT		
	Classification Index	*Means*	*Standard Deviations*
Classification Index	.....	713.8	33.32
Track Points	.317	931.2	171.49
	PUBESCENT		
	Classification Index	*Means*	*Standard Deviations*
Classification Index	.....	749.2	30.72
Track Points	.069	951.8	179.70
	POST-PUBESCENT		
	Classification Index	*Means*	*Standard Deviations*
Classification Index	.....	803.2	44.08
Track Points	.529	1244.0	248.00

TABLE III

CORRELATIONS, MEANS, AND STANDARD DEVIATIONS FOR CLASSIFICATION INDEX AND CHINS, DIPS, SQUAT-JUMPS, AND TWO-MINUTE SIT-UPS FOR PRE-PUBESCENT, PUBESCENT, AND POST-PUBESCENT GROUPS

	Classification Index	*Means*	*Standard Deviations*
PRE-PUBESCENT			
Classification Index	.....	643.8	33.33
Squat-jumps, Sit-ups, Chins, Dips	.003	117.1	46.36
PUBESCENT			
Classification Index	.....	750.8	29.57
Squat-jumps, Sit-ups, Chins, Dips	.047	125.2	46.94
POST-PUBESCENT			
Classification Index	.....	803.2	44.08
Squat-jumps, Sit-ups, Chins, Dips	.093	149.6	484.67

TABLE IV

CORRELATIONS, MEANS, AND STANDARD DEVIATIONS FOR CLASSIFICATION INDEX AND ENDURANCE FOR THE PRE-PUBESCENT, PUBESCENT, AND POST-PUBESEENT GROUPS

	Classification Index	*Means*	*Standard Deviations*
PRE-PUBESCENT			
Classification Index	.....	713.09	34.19
Endurance	.196	44.10	11.76
PUBESCENT			
Classification	.....	749.08	30.84
Endurance	.190	52.29	12.12
POST-PUBESCENT			
Classification Index	.....	803.20	44.08
Endurance	.097	50.90	9.93

CONCLUSIONS

On the basis of this study the following conclusions can be drawn:

1. There is an increase in strength in all three maturation groups when their Classification Index increases. This increase is greatest at the upper levels in the post-pubescent, is less pronounced in the pubescent, and is least in the pre-pubescent group. In the

lower classification indices, the stage of puberty has little influence on variations in the Strength Index.

2. An increase in motor achievement in selected track events can be predicted with some degree of certainty in the post-pubescent group when the classification indices increase. This is true to a lesser degree for the pre-pubescents but is of no predictive value when applied to the pubescent stage. The pre-pubescent boys tend to be slightly better in track performance than the pubescent boys.

3. The Classification Index has no predictive value for either circulo-respiratory endurance or for the combination of chins, dips, squat jumps, and two-minute sit-ups. The means of the circulo-respiratory endurance scores and of the combination of chins, dips, squat jumps and two-minute sit-up scores do increase significantly for the three maturation groups. (See Tables III and IV.)

4. In strength and in track and field athletics, the larger the boy (as determined by the Classification Index) the more is his performance influenced by changes in pubescence. This is more significant in strength performances, however, than it is in track.

5. Because of the relatively small number of cases in this sample, norms of strength and power cannot be established for the various pubescent groups. The establishement of such separate norms is needed.

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ACKNOWLEDGMENTS

The author wishes to express his most sincere appreciation to Dr. Norma D. Young and Dr. C. H. McCloy for their kind direction and many helpful suggestions in regard to the experimental work and the reporting of this study; and to the boys of Merrill Junior High School, Oshkosh, Wisconsin, who made the collection of data possible.

The Effect of a Simple Group Training Method Upon Myopia and Visual Acuity

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(Submitted for publication, December, 1947)

DURING the recent war years there were many requests, by candidates seeking admission to special branches of the military service, for training designed to decrease their myopia or to improve their naked visual acuity or to do both. The effectiveness and desirability of such training procedures is still open to dispute (1), and some investigators feel that further experimental work should be done. Hildreth, *et al* (2), in their report have stated: "Visual training merits further study particularly in relation to progress in myopia." Those who administer programs designed to improve every aspect of youth's fitness are just as interested in this general problem as are those individuals who are seeking ways of improving their vision so that they may be admitted to, or better perform, certain civilian or military duties.

Most methods which have been employed for the purpose of decreasing myopia or of improving naked vision are both time-consuming and expensive. It has been the purpose of the authors to investigate the effectiveness of a training procedure designed to be inexpensive and which would make but small demands upon an individual's time. This study was carried out at a boys' boarding school and the time schedule selected was one which interfered very little with the students' other appointments. To meet the demand for an inexpensive method only very simple equipment was used, the training was done in groups rather than individually, and the procedures, although supervised by an optometrist, were carried out by a technician who had had no previous experience with this type of work. It was fully appreciated by the authors that if this method of training failed to produce beneficial results it would be severely critized by those who feel that myopia is susceptible to improvement. It was not the purpose, however, to investigate the question as to whether ideal visual training methods can reduce myopia or improve naked vision acuity, but to make a preliminary study of the question as to whether ***this simple method*** would be effective. Unless this or a similar method

is proved to be a satisfactory aid in the reduction of myopia, or in the improvement of naked vision, little can be accomplished for the many schoolboys who ask for help. Methods requiring expensive equipment, experienced personnel, and a long training period may be of benefit to a few, but they can never hope to satisfy adequately the demand or to be incorporated as part of a general program designed to improve youth's fitness.

The studies recently published by Woods (1) and by Hildreth, *et al* (2), have discussed the whole question of the effect of visual training procedures upon myopia. Their methods of training were extensive and their preliminary and final eye examinations well controlled. Were it not that the entire purpose of the present study differed completely from theirs, the authors' results would not be reported. As has been stated, however, the purpose of this study was not to determine what could be accomplished in an ideal situation but only to determine what results one could obtain under conditions selected for their practicality. On the basis of Woods' investigation he concluded (1) that "education in the correct interpretation of a blurred visual image was the chief factor in the improvement noted" and that "with the possible exceptions of educating some patients to interpret blurred retinal images more carefully and of convincing some others they could see better even though there was no actual improvement, this study indicates that the visual training used on these patients was of no value for the treatment of myopia." Hildreth, *et al*, in their summary reported (2):

> There was no change in the refractive error, nor significant alteration in the ocular neuromuscular mechanism. It was thought that the improvement probably occurred because of an improved reception due to stimulation of the visual effort, as the best results occurred in those patients with a pre-training acuity less than would be expected from their refractive error since 73 percent of this type improved. . . Visual training has a definite, but limited, value in some myopic patients, preponderantly in those whose vision does not correspond with their known myopia. The effectiveness of visual training must be increased if it is to be generally applicable.

Their comment that the best results may be anticipated in a patient whose visual acuity is found to be less than one would expect from a determination of his refractive error is particularly significant, and should be of aid if one is interested in selecting those patients most likely to benefit from training procedures.

METHOD

Ten boys of high intelligence, ranging from 14 to 18 years of age, signified their desire to reduce their myopia and improve their naked visual acuity and were chosen for this study. There was no

selection of cases: the first ten who made their wish known were taken. On the basis of his preliminary visual examination one boy, who had a considerable degree of exotropia, was eliminated, and another subsequently dropped out because of lack of interest.

The preliminary and final visual examination consisted of the determination of the naked vision and the refractive error and measurements of heterophoria. A cycloplegic was not used. Both the preliminary and final examination four months later were made by the two ophthalmologists (AES and EBD) and the optometrist (WVE) upon the same day and with each refracting according to the method he was accustomed to use in his own office practice. Actually in practice only 2 refractionists would be needed to check refraction and one of these could supervise the training.

The training procedure was supervised by the optometrist (WVE) and was carried out by an assistant who had had no preliminary experience with this type of work. Prior to the beginning of the training session the optometrist and his assistant had a one-hour meeting at which time the methods to be used were explained, and similar meetings were held at the end of each four-week period. The optometrist was present at the first training session and at the subsequent ones in which new material was introduced. Each boy met with a group varying from three to seven members on three days a week. Sessions were held for seven consecutive weeks, omitted for three weeks (during a school vacation period) and resumed for a final five-week period. Each training session lasted one-half hour.

The only instrument used was a three-dimensional tachistoscope. During the first four weeks the slides known as the "Form Training Series" were used. In the second part of the training period the "Digit Training Series" was used: at first, two figures at 1/25 second were presented and later, four figures at 1/50 second. With this latter series the "Saccadic Fixation Training" slides were also used, chiefly in an attempt to maintain interest by varying the training material. At the beginning of the final third of the training period stereoscopic slides were introduced. At the beginning and end of each training period there was a brief opportunity for each of the trainees to note any visual change which might have taken place by reference to a modified Snellen chart. During the course of this investigation the trainees continued to wear the glasses which had previously been prescribed for them.

RESULTS AND DISCUSSION

The findings at both the preliminary and final visual examinations are shown in Tables I and II. There was, as one would expect, some slight variation in the results of the vision tests made

by the three examiners. In each case the value agreed upon by the three examiners as the best estimate of the subject's preliminary and final vision is given. When two of the three examiners obtained identical results, that value was chosen; when none of the three obtained the same result, a value approximately midway between the extremes was selected as being the best estimate. The measurements of heterophoria contribute little to this problem and are omitted for the sake of brevity; one individual found to have exotropia was eliminated from the training group, and others showed no more than slight degrees of muscle imbalance.

There was very little difference in an individual's naked vision determined by either the chart AO 1930 or AO 1942 (Table I). Six had exactly the same assigned value before training, and five obtained the same value, after training, on one chart as they did on the other. The two who varied before training (D.B. and R.W.) did so only in a slight degree; and the same was true of the three (L.L., K.S., and R.S.) who showed some difference in response to the two charts after training. In no instance did these estimates vary more than "one line" on the charts.

Comparison of the naked vision as determined on chart AO 1942 taken before training with that taken after training shows that

TABLE I

NAKED VISION AS DETERMINED ON THE AMERICAN OPTICAL COMPANY CHARTS AO 1942 AND AO 1930 BOTH BEFORE AND AFTER TRAINING

		AO 1942		AO 1930	
Name		*Assigned value before Training*	*Assigned value after Training*	*Assigned value before Training*	*Assigned value after Training*
D. B.	R	20/50	20/70	20/70	20/70
	L	20/50	20/50	20/70	20/50
J. C.	R	20/100	20/200	20/100	20/200
	L	20/100	20/100	20/100	20/100
W. D.	R	20/50	20/50	20/50	20/50
	L	20/50	20/50	20/50	20/50
L. L.	R	20/200	20/100	20/200	20/100
	L	20/100	20/70	20/100	20/100
K. S.	R	20/200	20/200	20/200	18/200
	L	20/200	20/200	20/200	20/200
W. S.	R	8/200	20/200	8/200	20/200
	L	8/200	20/100	8/200	20/100
R. S.	R	15/200	15/200	15/200	20/200
	L	13/200	18/200	13/200	18/200
R. W.	R	20/50	20/70	20/60	20/70
	L	20/20	20/30	20/20	20/30

in one boy (W.D.) the results for each eye, and in four other boys the results for one eye, were identical. In two boys (L.L. and W.S.) there was an improvement in naked vision of "one line" in each eye, and in one other boy (R.S.) there was a similar improvement in one eye. In one boy (R.W.) there was a decrease in naked vision in each eye, and in three others (J.C., K.S., and D.B.) there was a decrease in one eye. In all but one individual (L.L.) where the assigned value after training indicated an improvement in naked vision, this value indicated better naked vision than that obtained by any of the three examiners during the initial testing program. On the contrary, in only one boy (R.W.) where the naked vision had apparently decreased during the training period was the value assigned at the end of the training less than that found by any examiner prior to training.

Naked vision as determined by chart AO 1930 showed similar results. In one boy the assigned values before and after training were identical in both eyes and in three others, the same in one eye. In two (W.S. and R.S.) there was an improvement in naked vision of one line in both eyes and in two boys (D.B and L.L.) a similar improvement in one eye; of these all but D.B. showed some improvement on chart AO 1942. Two boys (K.S. and R.W.) showed a decrease in naked vision in both eyes and one other (J.C.) in one eye; these had also shown a reduction in the tests with chart AO 1942. In two trainees (W.S. and R.S.) who showed improvement no examiner had found the naked vision as high as the values assigned after training; among the four whose naked vision, as measured by this test, had decreased, there was one (K.S.) whose values were lower in each eye than those found initially by any examiner, and in one other trainee (R.W.) the value for O.S. was lower than any found initially.

These changes in naked vision seem hardly beyond the limits of error inherent in the tests. It may, however, be of some significance that on both charts L.L., W. S. and R. S. showed some improvement, and that also on both charts K.S., R.W., and J.C. showed some decrease in naked vision. In no instance was a change of more than "one line" found.

Any change in myopia which might be obtained by such a method is of considerable importance to this type of trainee. He is desirous not only of improving his vision, but also of decreasing his degree of myopia so that he may pass an eye examination of high standards. Table II lists the correction which each boy had been wearing prior to, and continued to wear during, the training period; and gives the results of retinoscopy before and after the training period. Retinoscopic values assigned after training indicated a decrease in degree of myopia in both eyes in no one, and in one eye

in two boys (L.L. and R.S.). In all the others there was a slight increase in myopia. In only two individuals (W.S. and R.W.), however, was the refractive error assigned after the training period greater for both eyes than that obtained by some one of the examiners at the initial examination; and in only two other boys (D.B. and K.S.) was it greater for one eye than that found initially. In each instance where a decrease in assigned refractive error was found in one eye (L.L. and R.S.), a value as low as this had been found initially by one examiner.

These changes in myopia are small and many are within the limits of error and of an individual's daily variation in refractive error. It is, however, difficult to believe that in any case there was any significant reduction in myopia.

Two of this group (D.B. and W.S.) had a pre-training visual acuity less than one would expect from a determination of their degree of myopia (2, 3). One of these (W.S.) did show some improvement in naked vision during the training period but he also apparently had a slight increase in refractive error during the same interval.

TABLE II

DEGREE OF MYOPIA AS DETERMINED BY EXAMINATION BEFORE AND AFTER THE TRAINING PERIOD, AND ALSO THE CORRECTION WORN BY EACH OF THE TRAINEES

Name		*Correction*	*Before Training*	*After Training*
D. B.	R	— .75 sph	— .75 sph	—1.00 sph
	L	— .75 sph	— .62 sph	—1.00 sph
J. C.	R	—3.00 sph	—3.12 sph	—3.50 sph
	L	—2.50 sph	—3.00 sph	—3.25 sph
W. D.	R	— .50 sph	— .62 sph	—1.00 sph
	L	— .50 sph	— .50 sph	—1.00 sph
L. L.	R	—1.50 sph	—2.25 sph	—1.75 sph
	L	—1.75 sph	—1.50 sph	—2.00 sph
K. S.	R	—2.75 sph	—2.75 sph	—3.25 sph
	L	—3.00 sph	—3.50 sph	—4.00 sph
W. S.	R	—2.00 sph	—2.50 sph	—3.00 sph
	L	—2.25 sph	—2.50 sph	—3.00 sph
R. S.	R	—1.75 sph	—3.75 sph	—3.50 sph
	L	—1.75 sph	—3.75 sph	—3.75 sph
R. W.	R	— .50 sph	— .62 sph	—1.00 sph
	L	— .50 sph	plano	— .75 sph

SUMMARY

1. Eight boys ranging in age from fourteen to eighteen years were given group training in an effort to determine whether a very simple method which could be managed by an inexperienced technician and which required only inexpensive equipment and relatively little of the trainee's time would be effective in improving vision or reducing myopia.

2. No significant change in naked vision or refractive error was obtained by this method, but the number of subjects studied was too small to permit one to draw conclusions regarding the possible value of this or other similar methods.

3. It is suggested that further similar studies be made and a method which meets the criteria listed under (1) above be developed if visual training is to be of widespread value as part of a national fitness program.

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Acknowledgments

The authors wish to express their appreciation of the courtesies extended them by the American Optical Company, The Keystone View Company, and The Three Dimension Company which generously loaned equipment, some of which was used in this study.

Objective Strength Tests of Affected Muscle Groups Involved in Orthopedic Disabilities

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Springfield College
Springfield, Massachusetts

Submitted for publication, December, 1947.

I. PREFACE

THE purpose of this project is to develop apparatus and objective techniques for measuring the strength of the affected muscle groups involved in orthopedic disabilities. Its accomplishment makes available to Army, Navy, and Veterans hospitals, to civilian general hospitals, to rehabilitation centers, and to corrective physical education departments in schools and colleges, objective measures for measuring gains in strength resulting from treatment of individuals with orthopedic disabilities. The unification of records and standardization of procedures for determining the extent of medical care thus made possible will provide more logical and standard methods of patient evaluation and will permit accurate interpretations of patient status to be made.

This project was initiated by Clarke and Peterson[1] while serving in the Physical Reconditioning Branch of the Army Air Forces Personnel Distribution Command during World War II. The tests were devised at the Army Air Force Convalescent Hospital, Bowman Field, Kentucky, and experimentation begun with nondisabled individuals at that post. Subsequently, the authors, under the supervision of orthopedic physicians, conducted a trial of the tests using patients with actual disabilities at the Army Air Forces convalescent hospitals located at Plattsburg, New York, and Miami Beach, Florida. However, it was not possible to determine the objectivity of these tests due to an insufficient number of patients with each disability at these hospitals. Also, the war ended, resulting in termination of the research.

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*Research conducted under subsidy from the Office of Naval Research, United States Navy Department.

1H. Harrison Clarke and Kjell J. Peterson. Strength tests of affected muscle groups involved in orthopedic disabilities. Unpublished manuscript, Springfield College, Springfield, Mass., 1945.

The present phases of the investigation into orthopedic strength testing, performed under subsidy from the Office of Naval Research, consisted of the following:

1. Conduct of precision studies of the testing technique previously devised utilizing as subjects non-disabled college students.

2. Modification of the testing techniques in accordance with this additional experience in administering the tests.

3. Trial, under medical supervision, of the testing techniques on patients with orthopedic disabilities at a Naval hospital.

The balance of this report is devoted to a description of the instruments and apparatus utilized in the orthopedic strength testing, descriptions of the various test items, and a report of the results of the research completed under Navy contract.

II. AVAILABILITY OF ORTHOPEDIC STRENGTH TESTS

A review of the literature related to orthopedic strength tests indicates limited availability of objective techniques in this area. Daniels, Williams, and Worthingham[2] reviewed extensively and analyzed critically "manual" orthopedic strength tests proposed between 1912 and 1946. Nearly all of these tests are dependent upon the subjective judgment of the examiner as he estimates the ability of the muscle to overcome gravity and outside force. The tests proposed by these authors also relied principally upon motion against gravity with various degrees of resistance applied manually by the examiner. The patient's strength status is graded in terms of "Normal," "Good," "Fair," "Poor," "Trace," "Zero," "Spasm," or "Contracture." Due to the lack of objective testing instruments and the large element of subjective judgment on the part of the examiner, these tests cannot be considered comparable to the objective techniques presented in this report. Their use, however, may still be necessary in types of disabilities not measurable with the new tests and in disabilities where only slight muscle contraction is possible or desirable.

In 1915, Lovett and Martin[3] proposed a spring balance test for measuring the strength of twenty-two muscle groups. In their tests, a sling was fastened to the extremity with the pull at right angle to the long axis of the limb. An assistant held the spring balance, fastened to the other end of the sling. The patient contracted the muscle being tested and held against the pull of the spring balance. The resistance registered represented the muscular strength.

2Lucile Daniels, Marian Williams, and Catherine Worthingham. *Muscle Testing*. Philadelphia: W. B. Saunders Company, 1947, p. 9-13.

3R. W. Lovett and E. C. Martin. Certain aspects of infantile paralysis with a description of a method of muscle testing. *Journal of American Medical Association*, 66: 732-733, 1916.

The Chatillon spring scale was used by Elbel[4] in studying the short static strength of muscles. In these tests, a Chatillon spring balance with a capacity of 120 pounds was used. The pull was made by a rope and pulley arrangement, with one pulley fastened to the wall at the desired height and the other hooked to the immobile end of the balance. The subject exerted pull from the free end of the rope, attempting at all times to make the effort in a uniformly continuous manner. In their early experimentation, Clarke and Peterson found that the spring balance was too heavy and clumsy for orthopedic testing, that it was difficult to record initial tensions on the scale, that the spring permitted the subject to pass the angle of best effort at the height of the pull, and that the range of motion permitted in taking the test could not be precisely controlled.

The need for improved objective tests for use in measuring the strength of affected muscle groups involved in orthopedic disabilities is evident from this survey of the availability of such tests.

III. TESTING INSTRUMENTS AND APPARATUS

In devising the orthopedic tests presented herein, several different types of instruments were examined in order to discover the one most applicable for measuring muscle strength. After studying various torque wrenches, tensiometers, dynamometers, and spring scales, the tensiometer-like instrument was selected as having greatest potentialities for this purpose. The other pieces of apparatus needed in the testing were devised from readily available material.[5] Following are descriptions of the testing instruments and apparatus needed in administering the orthopedic strength tests as finally constructed.

Tensiometer.[6]—The tensiometer, illustrated in Figure 1, is a small compact unit (4″ x 4″ x 1¼″), designed for testing the tension of aircraft control cables. Cable tension is determined by measuring the force needed to create offset (on riser) in the cable between two set points (the sectors). The cable tension may be converted directly into pounds on a prepared calibration chart attached to the inside of the cover of the tensiometer case.

The tensiometer is specifically designed to measure tension on an already taut cable. As a consequence, it was discovered that the instrument was not entirely accurate in measuring pulling force (the "up-pull") on a cable. This necessitated recalibration of the tensiometers used in this research, which was generously accom-

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[4]Edwin R. Elbel. A study in short static strength of muscles. Unpublished master's thesis, Springfield College, Springfield, Mass., 1928, p. 30.

[5]Clarke and Peterson, *op. cit.*

[6]Manufactured by the Pacific Scientific Co., Inc., 1430 Grande Vista Avenue, Los Angeles, Calif.

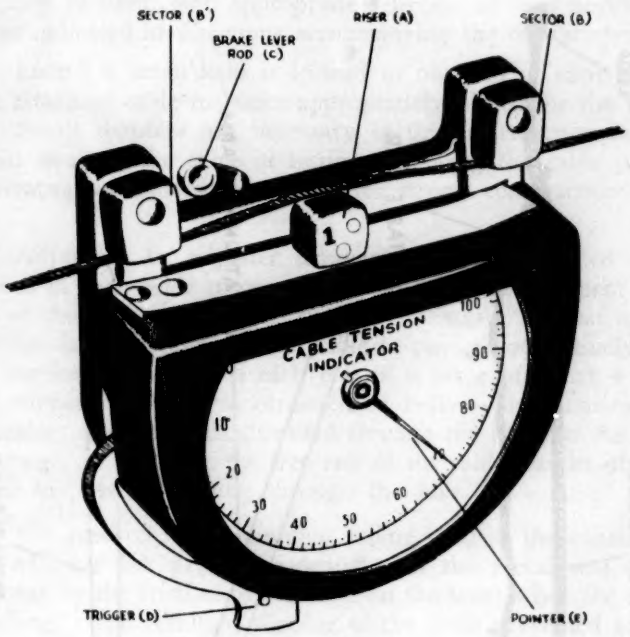

Figure 1. The tensiometer.

plished by the engineers of the Pacific Scientific Company, manufacturers of the tensiometer.

The initial work with the tensiometer was done with an instrument which measured cable tension up to 300 pounds. As this instrument would not measure accurately below 30 pounds, it was necessary to secure an additional, more sensitive tensiometer, from 5 to 100 pounds, for use with the smaller muscle groups and when testing muscles seriously weakened as the result of disabilities. Throughout the research, therefore, it was necessary to utilize two tensiometers: the heavier one when the strength is over 100 pounds; and the lighter, when the strength is under 30 pounds. Either instrument, of course, may be used when the strength is between 30 and 100 pounds. Actually, an instrument measuring to 200 pounds is adequate for the stronger pulls encountered.

Pulling Apparatus.—The pulling apparatus, illustrated in Figure 2, is homemade and consists of the following:

1. Cable: Two one-sixteenth inch extra flexible cables, preformed, 7 x 7, were utilized in this research. They are three feet six inches and six feet six inches long respectively. Other-sized

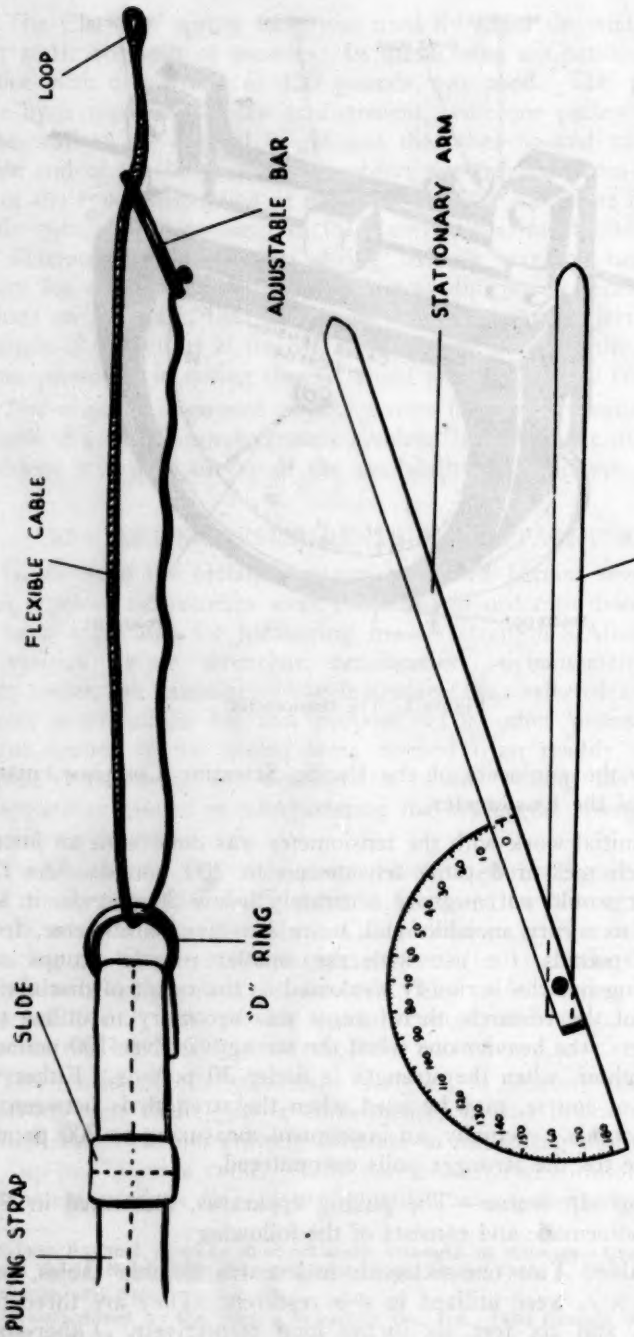

Figure 2. Top, the pulling apparatus; bottom, the goniometer.

cables may be used, with appropriate selection of riser and scoring table, as indicated in directions accompanying the tensiometer.

2. Loop: A small loop is formed at one end of each cable to permit attaching cable to hooks appropriately placed for the various tests. Small thimbles are necessary in this construction in order to avoid wear on the cable in testing. Splicing the cable junction and sweating in with solder completes strong construction of the loop.

3. Adjuster: An adjuster arrangement is constructed at the other end of each cable to permit easy and rapid adjustment in the length of the cable. This construction consists of (1) an adjuster bar: holes, large enough for the cable to pass through easily, were bored one-fourth inch from each end of a piece of metal 4 inches long (originally, this metal consisted of hollow aluminum tubing); (2) a cable: the cable was threaded through the holes in the tubing and through a "D" ring; the free end of the cable was knotted and soldered to prevent slipping through the hole.

In this research, the aluminum tubing used in the construction of the adjuster bar proved inadequate, as the metal was quickly worn away by the friction of the cable on the holes when the subject was pulling. The resultant slipping of the cable prevented accurate testing and might logically have proven injurious to the person taking the test, as the slipping often caused a sudden and unexpected jolt. After investigating different materials that would be more suitable for the adjuster bar, a regular 2 percent carbonated steel drill rod was selected. This metal was a great improvement over the tubing, but did not entirely solve the problem as some wear was evident around the holes of the adjuster bar after approximately 2,500 tests. Some cutting of the cable on the edges of the holes also occurred.

4. Strap: A pulling strap was attached by a "D" ring to the adjuster end of each cable for the purpose of placing around the patient's limb when pulling. The strap construction was as follows:

a. Double thickness of parachute webbing, *2′6″* long and *2″* wide, was formed in a loop and stitched around a "D" ring.

b. The adjuster end of the cable was threaded through the ring.

c. A slide was made from the parachute webbing and affixed to the pulling strap to permit adjustment of the size of the loop and in order to keep the loop snug around the patient's limb.

Testing Table.—A padded testing table, approximately *6′6″* long, *2′9″* wide, and *2′6″* high, is needed for placing the patient in correct position for the various pulls. The table should be

covered with some type of material that will prevent the subject from slipping. In this study, a regulation training-room (massage) plinth was used.

An additional testing table is necessary for the test, "extension of the leg at the knee joint," as the plinth is not high enough to permit passage of the cable under it at the proper angle. The supplementary table used in this study is illustrated in connection with Test No. 26. Any table high enough to permit the cable to pass under it at the desired angle may be utilized. It should be approximately 4 feet high and stable enough for the subject to sit on and be tested.

Supinator-Pronator Machine.—A supinator-pronator machine, as utilized in Tests 3 and 4, is required for testing supination and pronation strengths of the forearm. This instrment is standard gymnasium equipment mounted 2'9" from the floor (measured from floor to center of axle) if the arm of the subject taking the test is to be rested on the regulation plinth. All friction parts are removed from the machine, so as to permit free movement of the handle.

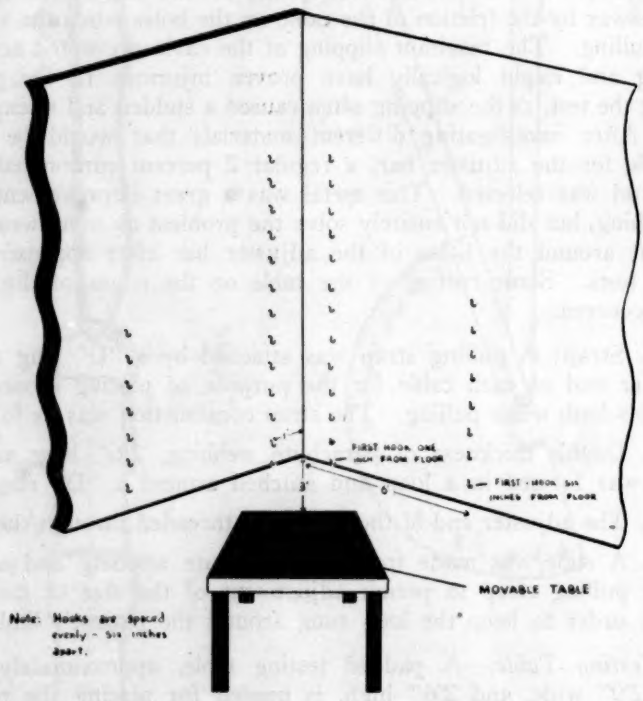

Figure 3. Spacing of hooks for orthopedic strength test.

A small hook placed at each end of the handle on the supinator-pronator machine is necessary in arranging the cable in position for the tests. The cable runs from the small hook on the handle to a large hook placed in the wall at the right or left of the machine.

Hooks.—A total of 47 four-inch, open-eye hooks, which will withstand pulls up to 200 pounds, are screwed into the walls and ceiling. The location and spacing of these hooks on the walls when a corner of a room only is available for testing are shown in Figure 3. They are arranged to facilitate attaching the cable at the proper angle of pull for the various tests. A single overhead hook is also required for Test Nos. 20, 27, and 28.

Goniometer.—The goniometer, illustrated in Figure 2, is used for measuring the angles specified in the various tests. This instrument consists of a 180° protractor made from plexiglass with two arms, 18 inches long, attached. One of these arms is stationary and extends along the zero line; the other is movable, permitting rotation to the proper angle.

Testing Area.—The lay-out of the testing area for efficient administration of the tests, when only a corner of a room is utilized, is given in Figure 3. Some moving of the testing table in order to obtain the correct angles of pull for the various tests is necessary in this lay-out.

An improved arrangement would be to utilize a small room with the table in the center and duplicate sets of hooks installed on all sides. This setup would eliminate all shifting of the plinth and reduce to a minimum the moving of the subject when taking any number of different tests.

IV. TESTING INSTRUCTIONS

The following instructions for administering the orthopedic strength tests relate to their application to non-disabled individuals. Their special application to individuals who have orthopedic disabilities will be considered later.

General Instructions

1. For each test in the orthopedic strength measurement sequence, the anatomical position of the joint for the application of pulling force is specified. Every effort has been made to eliminate compensatory action of muscles not involved in the joint movement. Thus, the positions of other parts of the body are given and the "blocking" supplied by the tester is prescribed. Precautions to observe in administering the various tests also appear in connection with the test descriptions.

2. The goniometer should be used for measuring joint angles specified in connection with each test. Instructions for using this

instrument are contained in "Exercises to Increase Joint Movements," Supplement to A. F. Manual No. 24, *Instructor's Manual for Physical ReTraining*, an Army Air Force publication.

3. The location of the strap on the patient's limb for each joint movement is so specified as to give best leverage for pulling.

4. The direction of pull (angle of cable and limb) is always 90°.

5. The cable should be taut when the patient is in proper position for the pull.

6. The cables should be stretched between two wall hooks when not in use in order to prevent them from becoming twisted and snarled.

7. The tester should adjust the joint being tested in such a way that the angle is approximately correct at the height of the pull.

Directions for Tensiometer Testing

1. Prepare tensiometer by mounting correct riser for the size of cable used for pulling (No. 1 riser, for 1/16″, 3/32″, and 1/8″ cables).

2. Place subject in correct position for the joint movement to be tested. Use goniometer in arriving at correct angles for specified joint positions.

3. Mount cable-pulling apparatus assembly and place around patient's limb as directed. Adjust slide so that pulling strap is snug. Tighten cable to taut position by moving adjuster bar.

4. Open trigger of the tensiometer and pass the cable between the two sectors and the riser. Close the trigger. Hold tensiometer in hand while testing. Precaution: Apply tensiometer to part of cable where there is a single strand only; testing on one of the double strands reduces record of pull.

5. The brake-lever rod should not be turned as it applies some pressure to the instrument and causes inaccurate testing. Turning the rod at the height of the pull in order to hold the reading position is permissible, although difficult. Careful observation of the pointer during the pull, visually noting its high point, was found to be the most desirable procedure.

6. Instruct subject to pull on cable and make as strong an effort as he can within his individual tolerance.

7. Take reading on dial of tensiometer.

8. Convert dial reading into pounds on calibration chart attached to inside cover of the tensiometer. Interpolate to deter-

mine pound force applied when dial readings are between those shown on the calibration chart. Interpolation below or above respective low and high "tension pounds" appearing on the chart, however, is inaccurate.

V. DESCRIPTIONS OF THE TESTS

This section of the report is devoted to a description of the orthopedic strength tests used in the study. The techniques utilized are, of course, patterned closely after those devised by Clarke and Peterson. However, some modifications are included as a result of this research, especially in prescribing the blocks applied by the tester to prevent the subject from using compensatory muscles in making his pull. Designations of the joint movements throughout the study are patterned after those appearing in Air Forces Manual No. 23, *Handbook of Recovery,* prepared at the Institute for Crippled and Disabled, New York, N. Y., and published by Training Aids Division Headquarters, Army Air Forces.

Photographs were taken of each of the tests in the Springfield College physical education testing laboratory. Drawings were made from the photographs, copies of which appear in connection with the appropriate test descriptions.*

A. Tests at Wrist Joint

1. Dorsal Flexion at Wrist Joint.

Starting Position:

(1) Patient sitting on chair; feet resting on floor.

(2) Arm adducted at shoulder to 180°; arm extended at shoulder to 180°.

(3) Elbow in 90° flexion; forearm in mid-prone and supine position.

(4) Wrist in mid-position of range of motion for dorsal and palmar flexion; forearm resting upon table; free arm on table bracing arm of wrist being tested.

Attachments:

(1) Center of strap around dorsum of hand 1" above the metacarpophalangeal joint.

(2) Cable attached to the wall facing palm of wrist being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions:

(1) Prevent arm abduction at shoulder; tester block elbow close to side of subject.

(2) Prevent elevation of shoulder; tester block on top of shoulder.

2. Palmar Flexion at Wrist Joint.

Starting Position: Same as for test of "dorsal flexion at wrist joint."

Attachments:

(1) Center of strap around palm of hand 1" above the metacarpo-phalangeal joint.

(2) Cable attached to wall facing dorsum of wrist being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions:

(1) Prevent arm abduction at shoulder: tester block elbow close to side of subject.

*These drawings will be found at end of article.

(2) Prevent elevation of shoulder: tester block on top of shoulder.

3. Supination of Forearm.

Starting Position:

(1) Patient sitting on chair; feet resting on floor.

(2) Arm adducted at shoulder to 180°; arm extended at shoulder to 180°.

(3) Elbow in 90° flexion; forearm resting upon table at right angle with wall.

(4) Forearm in 100° pronation; hand grasping handle of pronator-supinator machine; free arm on thigh.

Attachments:

(1) Cable attached to wall at right of supinator-pronator machine.

(2) Attachment to supinator-pronator machine at lower part of handle for right hand; attachment at upper part of handle for left hand.

(3) In case cable is attached to wall at left side of pronator-supinator machine, these positions will be reversed.

Direction of Pull: Parallel with horizontal plane and wall.

Precautions:

(1) Prevent dorsal flexion at wrist.

(2) Prevent arm abduction at shoulder: tester block elbow close to side of subject.

(3) Prevent lateral flexion of spine: tester block across top of shoulder on side being tested.

4. Pronation of Forearm.

Starting Position:

(1) Same as for test of "supination of forearm," except forearm in 80° supination (instead of 100° pronation).

Attachments:

(1) Cable attached to wall at right of supinator-pronator machine.

(2) Attachment to supinator-pronator machine at upper part of handle for right hand; attachment at lower part of handle for left hand.

(3) In case cable is attached to wall at left side of pronator-supinator machine, these positions will be reversed.

Direction of Pull: Parallel with horizontal plane and wall.

Precautions:

(1) Prevent palmar flexion of wrist.

(2) Prevent arm abduction at shoulder: tester block elbow close to side of subject.

(3) Prevent lateral flexion of spine: tester block across top of shoulder on side being tested.

B. Tests at Elbow Joint

5, 6, 7. Flexion of Forearm at Elbow Joint (in three positions).

Starting Position:

(1) Patient in supine lying position, hips and knees flexed; feet resting on table.

(2) Arm adducted at shoulder to 180°; arm extended at shoulder to 180°; forearm in vertical plane.

(3) Elbow in 90° flexion.

(4) Forearm (test each position in turn): (a) In as much *supination* as possible, (b) In as much *pronation* as possible, (c) Midprone-supine position.

(5) Hand of free arm resting on chest.

Attachments:

(1) Center of strap around forearm midway between wrist and elbow joints.

(2) Cable hooked to wall at patient's feet.

Direction of Pull: Parallel with median line.

Precautions:

(1) Adjust forearm so that the elbow is in 90° flexion at height of pull.

(2) Prevent shoulder elevation by bracing with hand.

(3) Prevent raising elbow and abducting upper arm by bracing elbow to side and hooking thumb over arm at elbow joint.

8. Extension of Forearm at Elbow Joint.

Starting Position:

(1) Same as for test of "flexion of forearm at elbow joint," except elbow at 110° extension.

Attachments:

(1) Center of strap around forearm midway between wrist and elbow joints.

(2) Cable hooked to wall at patient's head.

Direction of Pull: Parallel with median line.

Precautions:

(1) Adjust forearm so that the elbow is in 90° flexion at height of pull.

(2) Prevent shoulder elevation by bracing with hand.

(3) Prevent raising elbow and abducting upper arm by bracing elbow to side and hooking thumb over arm at elbow joint.

(4) Subject should keep head in straight alignment with body.

C. Tests at Shoulder Joint

9. Adduction of Arm at Shoulder Joint.

Starting Position:

(1) Patient in supine lying position, hips and knees flexed; feet resting on table.

(2) Arm adducted at shoulder to 160°; arm extended at shoulder to 180°.

(3) Elbow in thrust position; forearm in midprone-supine position; free arm on chest.

Attachments:

(1) Center of strap around humerus midway between shoulder and elbow joints.

(2) Cable attached to wall at side of patient's arm being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions:

(1) Prevent elevation of shoulder.

(2) Tester should aid by bracing shoulder with hand.

10. Abduction of Arm at Shoulder Joint.

Starting Position:

(1) Patient in supine lying position, with body diagonally across table, hips and knees flexed; feet resting on table.

(2) Arm abducted at shoulder to 110°; arm extended at shoulder to 180°.

(3) Elbow in thrust position; forearm in midprone-supine position; free arm on chest.

Attachments:

(1) Center of strap around humerus midway between shoulder and elbow joints.

(2) Cable attached to wall at patient's feet; near leg crosses cable.

Direction of Pull: Parallel with horizontal plane.

Precaution: Prevent shoulder elevation.

11. Flexion of Arm at Shoulder Joint.

Starting Position:

(1) Patient in supine lying position, hips and knees flexed; feet resting on table.

(2) Arm adducted at shoulder to 180°; arm flexed at shoulder to 135°.

(3) Elbow in thrust position; free arm on chest.

Attachments:

(1) Center of strap around humerus midway between shoulder and elbow joints.

(2) Cable attached to wall at patient's feet.

Direction of Pull: Parallel to median line.

Precautions:

(1) Prevent shoulder elevation.

(2) Tester should aid by bracing shoulder with left hand, and guide patient's limb with right hand to prevent rotation.

12. Extension of Arm at Shoulder Joint.

Starting Position: Same as for test of "flexion of arm at shoulder joint."

Attachments: Same, except cable attached to wall at patient's head.

Direction of Pull: Parallel to median line.

Precautions:

(1) Prevent shoulder elevation.

(2) Tester should aid by bracing shoulder with hand.

13. Inward Rotation of Arm at Shoulder Joint.

Starting Position:

(1) Patient in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.

(2) Arm adducted at shoulder to 180°; arm extended at shoulder to 180°.

(3) Elbow at 90° flexion; elbow supported by pad to bring upper arm into position parallel to table.

(4) Forearm in mid-prone supine position.

Attachments:

(1) Center of strap around forearm midway between elbow and wrist joints.

(2) Cable attached to wall at side of limb being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions:

(1) Adjust forearm so that it is vertical at height of pull.

(2) Prevent "cupping" shoulder by bracing with hand.

(3) Prevent raising elbow and abducting upper arm by bracing elbow to side and hooking thumb over arm at elbow joint.

14. Outward Rotation of Arm at Shoulder Joint.

Starting Position: Same as for test of "inward rotation of arm at shoulder joint."

Attachments: Same, except cable attached to wall at opposite side of limb being tested.

Direction of Pull: Parallel with horizontal plane.

Precautions:

(1) Adjust forearm so that it is vertical at height of pull.

(2) Prevent "cupping" shoulder by bracing with hand.

(3) Prevent raising elbow and abducting upper arm by bracing elbow to side and hooking thumb over arm at elbow joint.

15. Flexion of Shoulder Girdle (Forward humeral depressor test).

Starting Position:

(1) Patient in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.

(2) Arm adducted at shoulder to 180°; flexion of shoulder girdle to 45°.

(3) Elbow in thrust position.

Attachments:

(1) Center of strap around humerus midway between shoulder and elbow joints.

(2) Cable attached to wall at patient's feet.

Direction of Pull: Parallel with median line.

Precautions:

(1) Prevent hyperextension of trunk.

(2) Prevent shoulder elevation.

(3) Tester guide arm being tested by grasping hand or arm of subject.

16. Extension of Shoulder Girdle (Test for scapular rotators).

Starting Position: Same as test of "flexion of shoulder girdle."

Attachments: Same, except cable attached to wall at patient's head.

Direction of Pull: Parallel to median line.

Precautions:

(1) Prevent lifting shoulders off table.

(2) Tester guide arm being tested by grasping hand or arm of subject.

17. Upward Rotation of Scapula.

Starting Position:

(1) Patient in supine lying position, hips and knees flexed; feet resting on table; free arm on chest.

(2) Arm rotated to shoulder to 0°; arm upward rotated to 70°.

(3) Elbow at 90° flexion.

Attachments:

(1) Center of strap around humerus midway between shoulder and elbow joints.

(2) Cable attached to wall at patient's feet.

Direction of Pull: Parallel with horizontal plane.

Precaution: Prevent lifting shoulders off table.

18. Downward Rotation of Scapula.

Starting Position: Same as for test of "upward rotation of scapula."

Attachments: Same, except cable attached to wall at patient's head.

Direction of Pull: Parallel to horizontal plane.

Precaution: Prevent lifting shoulders off table.

D. Tests at Hip Joint

19. Flexion of Thigh at Hip Joint.

Starting Position:

(1) Patient in supine lying position, leg not tested resting on table; arms folded on chest.

(2) Thigh in 120° flexion at hip joint; thigh adducted at hip joint to 180°.

(3) Knee flexed.

(4) Place pad under free knee for comfort.

Attachments:

(1) Strap around thigh, lower third between hip and knee joints.

(2) Cable attached to wall at patient's feet.

Direction of Pull: Parallel with median line.

Precautions:

(1) Prevent lifting of leg not being tested.

(2) Prevent raising hip of leg being tested.
(3) Tester should aid by bracing hip not being tested.

20. Extension of Thigh at Hip Joint.

Starting Position:

(1) Patient in sitting position on table, legs hanging free; arms folded on chest.
(2) Thigh in 70° flexion at hip joint; thigh adducted at hip joint to 180°.
(3) Knee flexed.
(4) Place pad under free knee for comfort.

Attachments:

(1) Strap around thigh, lower third between hip and knee joints.
(2) Cable attached to overhead hook.

Direction of Pull: Parallel with vertical plane.

Precautions:

(1) Prevent lifting buttocks: brace against free leg.
(2) The upper trunk should be maintained in a strictly erect position with no forward motion permitted.

21. Adduction of Thigh at Hip Joint:

Starting Position:

(1) Patient in supine lying position; legs outside edge of table, hanging free; arms folded on chest.
(2) Thigh adducted at hip joint to 160°; thigh in 180° extension at hip joint.
(3) Place pad under knee of leg being tested.

Attachments:

(1) Strap around thigh, lower third between hip and knee joints.
(2) Cable attached to wall at side of limb being tested.

Direction of Pull: Parallel with horizontal plane.

Precaution: Prevent flexion of thigh at hip joint: brace against free leg and hip.

22. Abduction of Thigh at Hip Joint.

Starting Position:

(1) Patient in supine lying position; legs outside edge of table, hanging free; arms folded on chest.
(2) Thigh adducted at hip joint to 180°; thigh in 180° extension at hip joint.
(3) Free thigh flexed at hip to allow cable clearance.
(4) Place pad under knee of leg being tested.

Attachments:

(1) Strap around thigh, lower third between hip and knee joints.
(2) Cable attached to opposite wall from limb being tested.

Direction of Pull: Parallel with horizontal plane.

Precaution: Prevent flexion of thigh at hip joint; brace against hip being tested; prevent tilting of pelvis.

23. Inward Rotation of Thigh at Hip Joint.

Starting Position:

(1) Patient in sitting position on table, legs hanging free; arms folded on chest.
(2) Thigh in 90° flexion at hip joint; thigh adducted at hip joint to 180°.
(3) Knee in 90° flexion; padded support under knee.

Attachments:

(1) Center of strap around leg 4″ above ankle joint.

(2) Cable attached to wall on side away from limb being tested.

Direction of Pull: Parallel with horizontal plane and at right angles to median line.

Precautions:

(1) Prevent adduction and flexion of thigh at hip joint; tester should aid by bracing thigh with hands.

(2) Prevent eversion at ankle joint.

24. Outward Rotation of Thigh at Hip Joint.

Starting Position: Same as for test of "inward rotation of thigh at hip joint."

Attachments: Same, except cable attached to wall on side of limb being tested.

Direction of Pull: Parallel with horizontal plane, and at right angles to median line.

Precautions:

(1) Prevent abduction and flexion of thigh at hip joint; tester should aid by bracing thigh with hands.

(2) Prevent inversion at ankle joint.

E. Tests at Knee Joint

25. Flexion of Leg at Knee Joint.

Starting Position:

(1) Patient in prone lying position; arms folded above head.

(2) Thigh adducted at hip to 180°.

(3) Knee in 135° extension.

Attachments:

(1) Center of strap around leg midway between knee and ankle joints.

(2) Cable attached to wall at patient's feet.

Direction of Pull: Parallel with median line.

Precautions:

(1) Prevent lifting thigh and hips from table: brace hips with hands.

(2) Prevent inward or outward rotation at hip joint.

26. Extension of Leg at Knee Joint.

Starting Position:

(1) Patient in sitting position, legs hanging free; arms folded on chest.

(2) Thigh adducted at hip to 180°.

(3) Knee in 135° extension; padded support under knee.

Attachments:

(1) Center of strap around leg midway between knee and ankle joints.

(2) Cable attached to wall in back of patient.

Direction of Pull: Parallel with median line.

Precautions:

(1) Prevent lifting of buttocks: brace free thigh and hip.

(2) Prevent inward and outward rotation at hip joint.

F. Tests at Ankle Joint

27. Dorsal Flexion at Ankle Joint.

Starting Position:

(1) Patient in prone lying position; arms resting on table at side of head.

(2) Thigh adducted at hip joint to 180°; thigh in 180° extension at hip joint.

(3) Knee in 90° flexion.
(4) Ankle in 90° dorsal flexion; ankle in midposition of inversion and eversion.

Attachments:
(1) Center of strap around foot 1" above metatarsal-phalangeal joints.
(2) Cable attached overhead.

Direction of Pull: Parallel with vertical plane.

Precautions:
(1) Prevent inversion at ankle joint.
(2) Prevent flexion at metatarsal-phalangeal joints.
(3) Prevent raising knee; tester should aid by holding thigh against table.

28. Plantar Flexion at Ankle Joint.

Starting Position:
(1) Patient in sitting position on table, legs hanging free; arms folded on chest.
(2) Thigh adducted at hip joint to 180°.
(3) Knee in 90° flexion; padded support under knee.
(4) Ankle in 90° plantar flexion; ankle in midposition of inversion and eversion.

Attachments:
(1) Center of strap around foot above metatarsal-phalangeal joint.
(2) Cable attached to ceiling.

Direction of Pull: Parallel with vertical plane.

Precautions:
(1) Prevent lifting of buttocks (eliminate hip extensors).
(2) Prevent inversion or eversion at ankle joint.
(3) Prevent extension of metatarsal-phalangeal joints.
(4) Tester brace knee and leg to hold in proper position.

VI. PRECISION STUDY

The purpose of this phase of the research was to determine the objectivity coefficient[7] for each of the 28 orthopedic strength tests, as applied to non-disabled male students at Springfield College. Non-disabled subjects were used in the precision study for the following reasons:

1. In order to avoid such uncontrollable variables as pain, fear of injury, and general hesitancy on the part of patients to pull with an injured limb.

2. Because of reluctance to utilize patients in an experimental situation involving physical effort of injured parts.

As the precision with which the testing techniques can be applied was established on non-disabled subjects, it should be pointed out that similar results would not necessarily occur with patients unless they had been thoroughly oriented and accustomed to the tests. Application of the tests to patients, of course, should be done only under medical supervision.

[7] In physical testing, a measure is considered objective if two or more different testers, using the same instrument and applying the same techniques, secure similar results.

The precision study was conducted by two graduate students at Springfield College.[8] Each of the 28 tests was administered separately by the two investigators to 64 students chosen at random. The tests were given in groups of six to eight, selected in relation to minimum movement of the testing table and other adjustments in the administration of the tests.

Before any test scores were recorded, the investigators were carefully instructed in the proper techniques of administering the tests, after which demonstrations and practices were conducted. This instruction period provided appropriate skill in testing and experience with the tests before actually conducting the precision study. The subjects, however, did not receive practice in the tests prior to taking them.

For each group of tests, the same subjects were tested on the same day by both examiners independently. The tester not actually giving the test made the tensiometer readings and recorded them on a separate record form. Neither the tester nor the subject was permitted to see or hear each score as it was recorded. This precaution was taken both to eliminate the possibility of collaboration between the investigators and to prevent the motivation of "beating his score" on the part of the subject when taking the tests a second time.

Following the testing, a product-moment coefficient of correlation was computed between the scores obtained by the two testers on the 64 subjects for each of the 28 orthopedic strength tests. The resultant correlations appear in Table I, and are herein known as objectivity coefficients. It will be noted that 22 of the tests had objectivity coefficients of .92 and above; 12 of these were between .95 and .97. Six of the tests had coefficients lower than .90, but no test was below .84.

As .90 is the accepted standard indicating desirable objectivity and as tests with coefficients as low as .80 may be used for individual measurement, none of the 28 tests studied should be considered sufficiently unsatisfactory to warrant elimination from the battery. In order to double check the results obtained on the tests with objectivity coefficients below .90, however, precision studies were subsequently repeated on these six tests by two different investigators. The tests themselves were re-studied and appropriate changes made in their techniques. The two investigators* also practiced administering the tests until they had confidence in

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[8]George D. Mullen and Harlow A. Parker. A study to determine the objectivity of orthopedic strength tests as applied to non-disabled college men. Unpublished master's thesis, Springfield College, Springfield, Mass., 1947.

*Theodore L. Bailey and Charles B. Neff, graduate assistants at Springfield College.

TABLE I

OBJECTIVITY COEFFICIENTS OBTAINED BY MULLEN AND PARKER ON THE TWENTY-EIGHT ORTHOPEDIC STRENGTH TESTS

Classification	*Name of Test*	*Objectivity Coefficients*	
Tests at Wrist Joint	1. Dorsal Flexion at Wrist Joint	.86	.95*
	2. Palmar Flexion at Wrist Joint	.93	
	3. Supination of Forearm	.91	
	4. Pronation of Forearm	.95	
Tests at Elbow Joint	5. Flexion of Forearm at Elbow Joint (Midprone-Supine Position)	.84	.96*
	6. Flexion of Forearm at Elbow Joint (In as much Supination as possible)	.92	
	7. Flexion of Forearm at Elbow Joint (In as much Pronation as possible)	.95	
	8. Extension of Forearm at Elbow Joint	.88	.94*
Tests of Shoulder Joint	9. Adduction of Arm at Shoulder Joint	.94	
	10. Abduction of Arm at Shoulder Joint	.94	
	11. Flexion of Arm at Shoulder Joint	.94	
	12. Extension of Arm at Shoulder Joint	.97	
	13. Inward Rotation of Arm at Shoulder Joint	.84	.94*
	14. Outward Rotation of Arm at Shoulder Joint	.89	.93*
	15. Flexion of Shoulder Girdle	.94	
	16. Extension of Shoulder Girdle	.96	
	17. Upward Rotation of Scapula	.94	
	18. Downward Rotation of Scapula	.97	
Tests at Hip Joint	19. Flexion of Thigh at Hip Joint	.92	
	20. Extension of Thigh at Hip Joint	.86	.93*
	21. Adduction of Thigh at Hip Joint	.97	
	22. Abduction of Thigh at Hip Joint	.96	
	23. Inward Rotation of Thigh at Hip Joint	.95	
	24. Outward Rotation of Thigh at Hip Joint	.95	
Tests at Knee Joint	25. Flexion of Leg at Knee Joint	.97	
	26. Extension of Leg at Knee Joint	.94	
Tests at Ankle Joint	27. Dorsal Flexion at Ankle Joint	.95	
	28. Plantar Flexion at Ankle Joint	.96	

*Obtained on revised form of test.

their ability to give them. Very satisfactory results were obtained as shown in Table II.

TABLE II

OBJECTIVITY COEFFICIENTS OBTAINED BY BAILEY AND NEFF FOR REVISED FORM OF SIX TESTS FOUND BELOW .90 IN INITIAL STUDY

Name of Test	*Objectivity Coefficients* *Initial Tests*	*Revised Tests*
1. Dorsal Flexion at Wrist Joint	.86	.95
5. Flexion of Forearm at Elbow Joint (Midprone-Supine position)	.84	.96
8. Extension of Forearm at Elbow Joint	.88	.94
13. Inward Rotation of Arm at Shoulder Joint	.84	.94
14. Outward Rotation of Arm at Shoulder Joint	.89	.93
20. Extension of Thigh at Hip Joint	.86	.93

As the result of the re-study of these six tests, some modifications in testing techniques were found desirable. Such changes dealt primarily with specification of additional body blocks and listing additional precautions to prevent the subject from utilizing muscle groups other than those being tested in making his pull. Tests 5 and 8, flexion and extension of forearm at elbow joint, gave greatest difficulty due to the subject's desire to bring extraneous muscles into play. Eventually, however, these tests were modified so as to permit accurate testing when the techniques are carefully applied. The changes resulting from this additional study of the six tests have been incorporated into the test descriptions previously given.

Without doubt, one of the greatest difficulties in administering this type of test is to isolate the *effect* of the muscles controlling the specific joint movements and to eliminate the *effect* of compensatory muscles. Considerable care, therefore, must be taken in the use of the tests to follow the specific instructions for the various testing techniques, especially as they pertain to the precautions listed and the blocks specified.

A number of important observations were made by the various investigators in conducting the precision study which will aid materially in the availability and cost of testing equipment, in the durability of testing instruments, and in the ease of test administration. Proposals based on their findings are included among the recommendations made at the end of this report.

VII. TRIAL OF TESTS ON ORTHOPEDIC PATIENTS

Following the improvement of testing techniques and the precision study, arrangements were made to try the orthopedic strength tests on patients with orthopedic disabilities at the U. S. Naval Hospital, Chelsea, Mass. The purpose of this trial was to determine the appropriateness of the tests when applied to individuals

with actual disabilities and to discover additional modifications of testing techniques necessary under these conditions.

The hospital trial was conducted from August 11-15, 1947, by the writer with the assistance of the graduate students who conducted the precision study.*

The procedure followed in this phase of the study was to try out the tests on as many patients as were available and who were, in the opinion of the physicians, sufficiently far along in their recovery so as to suffer no ill effects from the exertion attendant upon taking the tests. Fortunately, the distribution of patients at the Chelsea Naval Hospital at the time of the trial was such as to provide subjects for each of the joint movements involved. In testing, of course, each patient was given only those tests which applied to his particular disability. Corresponding tests with the uninjured limb were also given for purposes of comparison. The trial at the Chelsea hospital was particularly fortunate in that the patients were accustomed to pulling through the use of heavy resistive exercises in their physical rehabilitation program.

The disabilities encountered in the hospital trial included the following: bone-pegging operations, gunshot wounds, fractures with both open and closed reductions, arthritis, arthrotemies, bursitis, and ruptured intervertebral disk. Patient status ranged from those in the early stages of convalescence to those who were ready for return to duty. Two case studies only are given for illustrative purposes, as follows:

Case No. 2: Gunshot wound in left forearm, October, 1946: compound fracture of upper radius bone; bone plates used. Bone graft operation done, February 1947; cast removed three months later; physiotherapy and physical rehabilitation begun. Patient also had medium and radial nerve envolvements of left forearm; progress satisfactory.

Tests	*Injured*	*Uninjured*
Flexion of forearm at elbow joint (midprone-supine)	13	41
Flexion of forearm at elbow (supination)	10	36
Flexion of forearm at elbow (pronation)	6	30
Extension of forearm at elbow joint	19	41

Case No. 7: Head-on truck collision: multiple fractures of face and pelvis: pelvis fracture extending into acetabulum on left side; became ambulatory on crutches two months before trial. Gradual weight-bearing one month later; at time of trial was walking on crutches without pain; full range of motion in left hip; muscles of

*George D. Mullen and Harlow A. Parker. The trial was supervised by the orthopedic physicians at the Chelsea Hospital, Comdr. Edward T. Haslam, MC, USN, in charge. In addition to Comdr. Haslem, acknowledgements for this supervision are made to Lieut. (jg) Frank C. Doyle, MC, USNR, and Lieut. (jg) Robert D. Heath, MC, USNR. Miss Eileen F. Haydock, Reg. PT, also assisted with the testing.

left thigh partially atrophied. Treatment now consisting of extensive physiotherapy and physical rehabilitation.

Tests	*Injured*	*Uninjured*
Flexion of thigh at hip joint	31	55
Extension of thigh at hip joint	43	67
Adduction of thigh at hip joint	13	31
Abduction of thigh at hip joint	31	33
Inward Rotation of thigh at hip joint	19	26
Outward rotation of thigh at hip joint	16	26

In conducting the trial, the appropriateness of the various tests when applied to patients recovering from disabilities was determined by observation. In each instance, a physician at the hospital checked the test application and made suggestions when they appeared desirable. An examination of each patient on the day following his testing to discover if undesirable after-effects were present aided in forming a sound evaluation of the procedures.

The results of the trial of the strength tests upon patients with orthopedic disabilities at the Chelsea Naval Hospital were considered satisfactory. In general, they coincided well with medical opinion of patient status. Physicians, technicians, and patients were definitely interested in the objective scores thus made possible. Dr. Haslam, one of the supervising orthopedic physicians at Chelsea Hospital, rendered his opinion in a formal letter, which contained the following significant points:

1. No complications or sequaella occurred which was attributable to the testing. The physicians believed that, if such had been the case, it would not mean that the tests were unsuitable but rather that the patients were not ready for strong exertion.

2. In general, the test results were consistent with the impressions of the physicians and with the results previously noted by measurements and by the amount of weight the patient could lift.

3. The tensiometer-type of testing has an advantage in that the pull is constant for a long-enough period to permit the examiner, by inspection and palpation, to ascertain which tendons are in a state of tension, and thus aid in the interpretation of the results.

4. The tests might prove to be of value in deciding whether muscle strength was adequate to permit satisfactory arthroplasty, after a series had been followed with these tests and the muscle strength checked with the results obtained following surgery.

5. The tests could be used advantageously in following patients, who had been put on intensive physical rehabilitation, as a means of determining progress and need of revision of their exercises.

6. The test readings are unknown to the patient while taking the test, which would not be true were he lifting known weights, thus making it difficult for him to produce wilfully low readings which would be consistent from day to day or week to week. Also,

patients wishing to appear more fully recuperated than is actually the case could be easily detected.[9]

As a result of the testing trial, the following directions were found appropriate when applying the tests to patients and are given in addition to the testing instructions appearing in Section IV of this report:

1. Strength testing of affected muscle groups involved in orthopedic disabilities should be accomplished under supervision of appropriate medical authority. In medical practice, of course, such tests as these should be considered as supplementary measures to other medically prescribed means of evaluation.

2. Where tenderness in the joint area is present and the patient experiences some pain in pulling, he should be instructed not to pull beyond the force he can apply comfortably. In such instances, the full strength of the muscle group is not measured; but rather, the patient's application of strength only is recorded.

3. If the range of motion in the patient's injured limb is limited, thus preventing assumption of prescribed joint angles, the tester should make necessary allowances until it improves sufficiently to permit proper positions to be taken.

4. Changes in the position of the strap applied to the patient's limb should be made by the tester if the prescribed position is uncomfortable in individual cases.

5. Where a large number of tests are proposed around a single joint, which is particularly true of the shoulder, it is desirable to either select the specific tests needed or give all the tests at the first testing period and subsequently repeat only those showing deficiencies. In some instances, too, it may be advisable to spread the testing over more than one day.

VIII. CONCLUSIONS

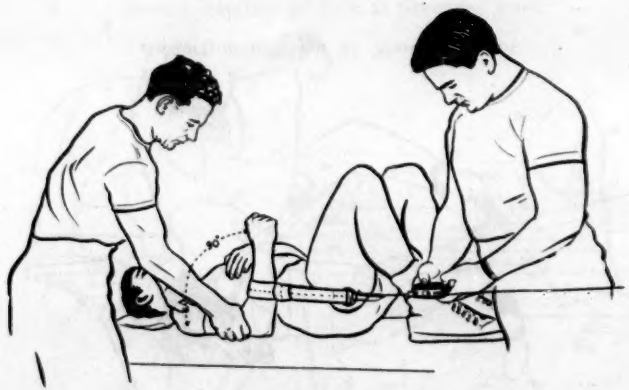
This research project should be considered a first exploratory effort into objective testing with the apparatus and techniques herein described. The evidence presented indicates that the tests can be given accurately when measuring the strength of muscles controlling the 28 joint movements studied, and can be used on patients when administered under medical supervision.

However, improvements in the apparatus and techniques are possible. Plans have been made and research started to study the effectiveness of different joint angles and strap positions for the various tests. Tests for joint movements not included in this study will be devised, norms constructed, and the testing apparatus standardized and made readily available.

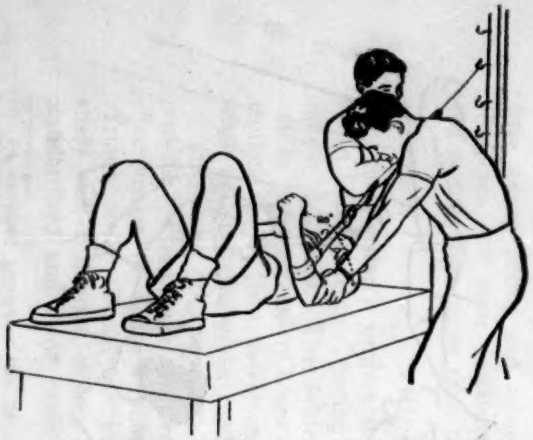
[9] A detailed report of the 19 case studies and the complete letter written by Dr. Haslam appear in the report of this research submitted to the Office of Naval Research and deposited in the Springfield College Library.

Dorsal Flexion at Wrist.

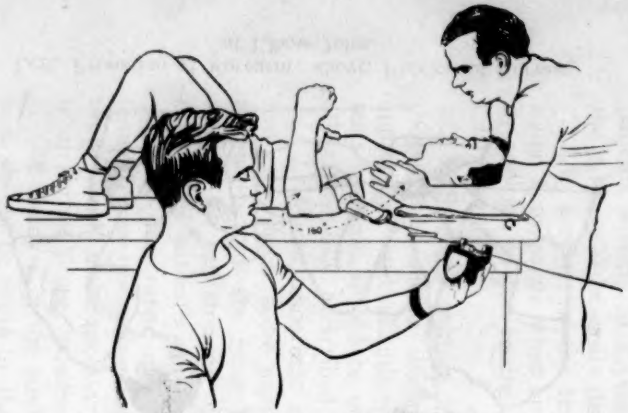
Palmar Flexion at Wrist.



Left, Pronation of Forearm; above, Flexion of Forearm at Elbow Joint.



Extension of Forearm at Elbow Joint.



Adduction of Arm at Shoulder Joint.

Left, Abduction of Arm at Shoulder Joint; above, Flexion of Arm at Shoulder Joint.

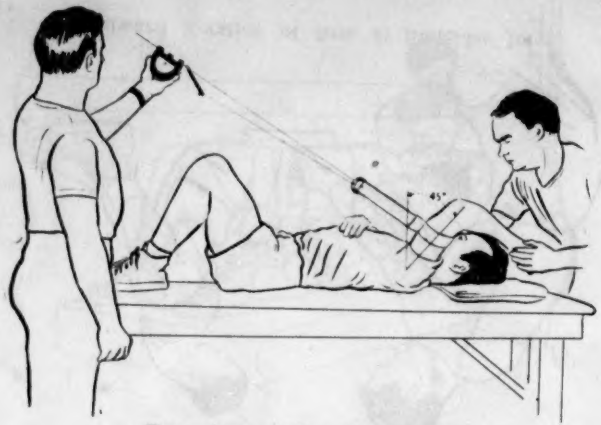
of Arm at Shoulder Joint.

Extension of Arm at Shoulder Joint.

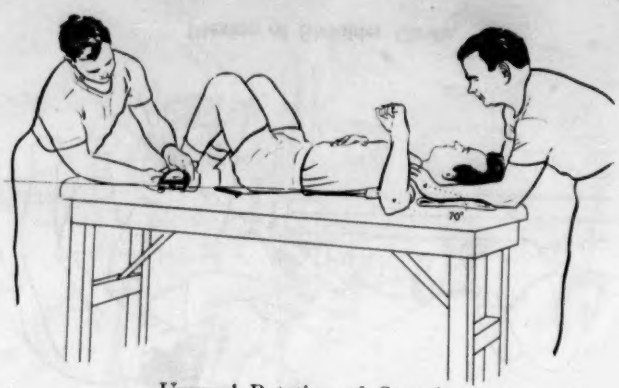
Inward Rotation of Arm at Shoulder Joint.

Outward Rotation of Arm at Shoulder Joint.

Flexion of Shoulder Girdle.



Extension of Shoulder Girdle.



Upward Rotation of Scapula.

Left, Downward Rotation of Scapula; above, Flexion of Thigh at Hip Joint.

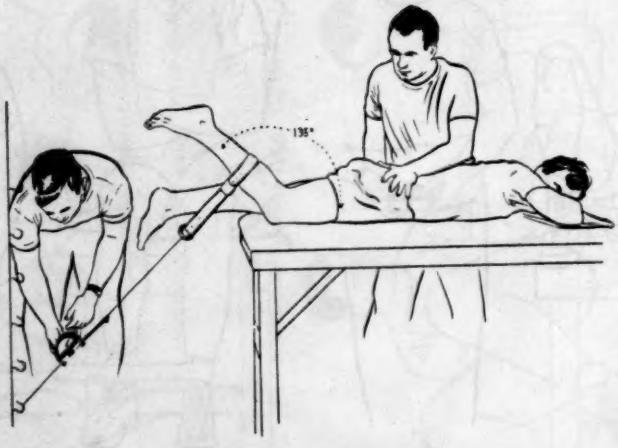
Extension of Thigh at Hip Joint.

Adduction of Thigh at Hip Joint.

Abduction of Thigh at Hip Joint.

Inward Rotation of Thigh at Hip Joint.

Outward Rotation of Thigh at Hip Joint.



Flexion of Leg at Knee Joint.

Extension of Leg at Knee Joint.

Dorsal Flexion at Ankle Joint.

Plantar Flexion at Ankle Joint.

Research Abstracts

PREPARED FOR THE
NATIONAL COUNCIL OF THE RESEARCH SECTION
BY GRANVILLE B. JOHNSON
University of Denver

ANATOMY

Wright, Robert R., Barry J. Anson, Henry C. Cleveland, "The Vestigial Valves and Interaterial Foramen of the Adult Human Heart: An Anatomic Study of 512 Specimens," *Anat. Rec.*, 100: 3 (March, 1948).

Records are presented on the size of the crista terminalis (443 specimens), of the caval valve (512 specimens), and of the valve of the coronary sinus (in 226 hearts).

The valve of the inferior vena cava and the valve of the coronary sinus are discussed also on the basis of form and interrelationhips.

It is established that a greater degree of readjustment has occurred in the lateral wall of the right atrium than in the area superolateral to the orifice of the inferior vena cava; in the latter area the crista and the caval valve are likely to remain in close relation with each other. The area of the medial extremity of the caval valve and limbus of the fossa ovalis is close to the interatrial septum.

Interatrial communications were studied; an anatomical patency occurs in 22.9% of cases, a physiological patency, in 0.8%.

A true Chiari network was found in only 1 heart of 512 studied. In 9 other cases, fibrous cords or strands were found attached to the edge of the caval valve, their other attachment, however, being to the adjoining atrial wall and not to the medial extremity of the crista terminalis (as originally described by Chiari).

The character of the valve of the foramen ovale and the nature and size of the recesses in the atrial septum are recorded for 215 specimens.—*Wistar Institute.*

GENERAL EDUCATION

Fattu, Nicholas A., "Some Relationships Between Indices of School Adequacy and Certain Measures of Pupil Achievement," ***Bulletin of the School of Education,*** Indiana University, 23: 6 (Nov., 1947), pp. 21-32.

Rural pupils entering the University School, Bloomington, Indiana, during the falls of 1946 and 1947 were investigated for the study. Tests were given to the pupils shortly before they graduated from the eighth grade. The tests given included the California Test of Mental Maturity, the Otis Self-Administering Group Intelligence Test, the Cooperative English Test C-1, and the Cooperative Arithmetic Test. Comparisons of scores were made in terms of percentile ranks.

Ratings of school adequacy divided into 20 items were made independently by two raters. The lower score on ratings indicated the poor practices in the schools from which the pupils came.

The rural group of pupils was found to be much closer to the average in total group performance on the intelligence test than it was on the reading and arithmetic tests. Ratings of the school environment seemed to correlate slightly higher with the test scores than did ratings of learning atmosphere, but the difference was too small to be significant. In each instance the correlations were positive and significantly different from zero.

The results indicate that there was a definite relationship between the ratings of school adequacy and the performance of pupils on certain objective tests. This study answers the question, "Do good schools pay?" with an emphatic "Yes."—*Carolyn W. Bookwalter.*

Milligan, E. E., L. Joseph Lins, and Kenneth Little, "The Success of Non-High School Graduates in Degree Programs at the University of Wisconsin," *School and Society,* 67: 1724 (Jan. 10, 1948), pp. 27-29.

From September, 1945, to June, 1947, 72 non-high school graduates were admitted to degree programs. These were admitted upon a standard of an *average* percentile ranking of 55 on the General Educational Developmental Tests, high school level, and the American Council Psychological Examination for College Freshmen and the approval of the dean of the college in which the students enrolled. Of the 72, 68 enrolled for courses. Sixteen withdrew before the conclusion of the second semester of 1946-1947. In addition, 6 were dropped by action of the dean of the respective college.

It was found that there is no apparent relation between the number of high school units completed and in university success. Of the measures used, the best in terms of predicting university success seems to be the Correctness and Effectiveness of Expression, General Education Test I, the composite of the five General Education Tests, and the American Council Psychological Examination for College Freshmen. The latter is useful as a predictive measure of university success only at the upper and lower percentile levels, above 70 and below 30.—*Carolyn W. Bookwalter.*

Shaffer, Robert H., "The Effect of English Deficiency Upon a Student's Adjustment in College," *Bulletin of the School of Education,* Indiana University, 24: 1 (January, 1948), p. 34.

Two hundred and forty-three students from the entering classes of 1940, 1941, and 1942 at Indiana University fell into the category of deficient student (those who ranked in the lowest decile of his class on Cooperative English Test). Three aspects of their adjustment in college were considered: scholastic adjustment, social adjustment, and emotional adjustment.

The analysis of adjustment included comparison of deficient and non-deficient students relative to their scholastic records in various subjects to discover whether English was more significant in determining grades received in some subjects than in others, a comparison of deficient and non-deficient students' scholastic records over several semesters to observe trends, a comparison of scores on the Bernreuter Inventory, a comparison of participation in various group activities, and a comparison of various social habits.

The study revealed that the English-deficient student passed significantly fewer hours for at least the first three semesters of their college careers than the non-deficient students. However, the deficient students were found to be more extroverted, more dominant, and more self-confident during the first semester but became less dominant, less confident, and less social as they remained in college.—*Carolyn W. Bookwalter.*

NUTRITION

Wynn, Winfrey, and John Haldi, "The Erosive Action of Various Fruit Juices on the Lower Molar Teeth of the Almino Rat," *J. Nutrition,* 35: 4 (April, 1948).

Erosion in the lower molar teeth of the albino rat resulted from the daily ingestion of each of the following canned fruit juices when they served as the sole fluid intake over a period of 100 days; apple, grape, orange, tomato,

sweetened grapefruit, pineapple, and prune. The greatest amount of erosion occurred in the teeth of the animals on apple, grape, and grapefruit juice. the least in those of the animals on tomato and prune juice. Erosion of a milder degree also resulted from the ingestion of tomato, orange, and sweetened grapefruit juices 3 times a day for 200 days. While there seemed to be a general tendency for the degree of erosion to increase with an increase in the acidity of the juice ingested, there was not a strict and invariable correspondence between the acidity and the amount of tooth destruction.—*Wistar Institute.*

Hegsted, David M., "The Determination of Minimum Vitamin Requirements for Growth," *J. Nutrition,* 35: 4 (April, 1948).

The usual method used in the determination of growth requirements is to feed various levels of the nutrient and then to test statistically the difference in response between the various levels to determine at which level one ceases to obtain a significant increase in response. Almost invariably small groups of animals must be used. Thus, most of the data are discarded in making the critical test at exactly the point at which large groups are required to show the small differences to be significant, and the most likely error is that one will conclude that the groups are not different when in fact they may be. This type of error will invariably lead to a low estimate of requirement. A low estimate is considered a more serious error than the less likely overestimation since one is interested in setting requirements high enough to cover adequately all of the individuals. It is suggested that, by plotting a log dose-response curve and determining the point at which the regression line, drawn through the region of approximately linear response, reaches maximum growth, one arrives at a fairer estimate of the true requirement. The maintenance requirement, that amount of nutrient required to give just zero gain, may also be determined with considerable accuracy from the same regression line.—*Wistar Institute.*

Blanchaer, Marcel C., Eileen Cameron, "The Relation of Thiamine Clearance to Blood Levels in Man," *J. Nutrition,* 35: 3 (March, 1948), pp. 391-392.

Simultaneous blood thiamine and clearance estimations were made on 23 hospital patients. Low clearance values were found in the more severly ill subjects, while convalescent patients and those under investigation for minor ailments excreted larger amounts. In the group excreting less than 90 ug of thiamine, severely ill subjects were found to have higher blood levels. There was a significant negative correlation between blood levels and thiamine clearance below 90 ug.—*Wistar Institute.*

Johnston, Frances Ann, Ruth Frenchman, and Euphemia D. Boroughs, "The Absorption of Iron from Beef by Women," *J. Nutrition,* 35: 4 (April, 1948).

Five young women 18 years of age and in good health, with normal serum iron, hemoglobin, and red cell counts, were placed on a diet containing 7 mg of iron which was judged to be the lowest intake that would be adequate. After 6 weeks on the basal diet, 2 100-gm patties of ground beef (2/3 lean meat, 1/3 fat) containing 3.4 mg of iron were added, 1 at breakfast and 1 at lunch. The increase in retention after the addition of the beef was considered as iron absorbed from the beef. The percentages of absorption of iron from beef for 4 out of 5 subjects were 32, 45, 58, and 57 respectively. This led to the conclusion that young women 18 years of age on an adequate diet absorb from about one-third to more than one-half of the iron of beef. Another interpretation of the results is more likely the correct one, namely,

that the beef improved the absorption of the iron of the entire food mixture, rather than itself contributing all of the iron absorbed after it was added to the diet.

If the amount of iron added to the food residue as it passes through the gastrointestinal tract can be regarded as negligible, the mean absorption from the basal diet was 11% and was increased to 21% after the first addition of beef.—*Wistar Institute.*

PHYSICAL ANTHROPOLOGY

Rife, David C., "Genetic Variability within a Student Population," *American J. Phys. Anthrop.*, n. s., 6: 1 (March, 1948).

Data concerning the incidence of the blood groups, the M and N blood types, RH antigens, ability to taste phenyl-thio-carbamide, handedness, whorls on fingers, patterns on palms, and hair color were obtained from approximately 1,850 students at Ohio State University. Comparisons were made between the frequencies of these traits among white students grouped according to religion and among negro students. The following differences of statistical significance were noted: (1) Jewish individuals are characterized by higher frequencies of blood groups B and AB and a lower frequency of group O than are either the Prostestants or the Catholics, (2) the negroes have a lower frequency of group A and a higher frequency of Group B than any of the other populations, (3) marked differences are apparent in regard to percentages of tasters, the negroes showing the highest and the Catholics the lowest, (4) the Jewish group showed more left-handedness than do the Protestants, (5) the Jewish group showed a higher frequency of whorls than do any of the other populations, (6) the Protestants show the lowest frequencies of palm patterns of all the populations, and (7) there are marked interpopulation differences in hair color.—*Wistar Institute.*

PHYSICAL EDUCATION

Patt, H. M., "Evaluation of Certain Tests of Physical Fitness," *J. Aviat. Med.*, 18 (April, 1947), pp. 169-175.

The physical fitness of 105 Navy and Marine Corps personnel was determined by a performance criterion involving preliminary fatigue from vigorous calisthenics interspersed with short hikes during the day. The criterion itself was a 23.5 mile run done in the evening with combat equipment; it required about 18 hours. Motivation was aided by promising 3-day leaves for the men who competed the run. Some 49 percent failed to finish, although most of these managed to keep going for 9 or more hours.

Previously, scores had been obtained on a variety of physical fitness tests. Those that failed to discriminate between criterion success and failures include:

AAF test (sit-ups, pull-ups, and 300-yd. run)	$r = .01$
Dynamometer fatigue test	$r = .06$
Systolic, pulse pressure and heart rate on the tilt table	$r = .01$ and $.06$
Ray blood reduction test	$r = .30$ and $r = .05$

Tests showing significant validity (in terms of the biserial correlation with pass-fail on the 23.5 mile run) are:

Body sway (*ataxiagraph* or *stabilometer*)	$r = .43$
Medical Officers rating (pre-test)	$r = .37$
Steps completed in the step-up test	$r = .32$

In the failure groups, criterion time scores correlate $r = .45$ with body sway, $r = .37$ with medical rating, and $r = .16$ with step-test scores. These three tests predict the criterion with a multiple R of .51.

The "failure" group showed significant post-fatigue impairment in the blood reduction test (CR = 5.1), body sway (CR = 4.0), and the dynamometer test (CR = 3.0). In the "success" group, these changes were smaller. —*F. Henry.*

Van Dalen, D.B., "A Differential Analysis of the Play of Adolescent Boys," *Journal of Educational Research* (Nov., 1947), pp. 204-213.

McCloy's modification of Strength Index was administered to 348 boys in grades 7, 8, and 9 of ages 12 to 16. The Physical Fitness Index was derived from the composite score of the modified Strength Index (right and left grip, back and leg lift, and chinning and dipping) by a norm based on age, weight, and sex.

A play questionnaire, including a list of 150 activities, was given to the boys so that for every day for one week the students recorded their play participation and amount of time devoted to each. This procedure was repeated at three different intervals during the year (September, February, May).

Boys of high Strength Index and Physical Fitness Index (modified forms) exceeded by a minimum of 5 times the boys in the low Strength Index and Physical Fitness Index groups in the total excess number of frequencies of participation.

Boys in the low strength groups participated in games somewhat individualistic in nature and of lower degree of organization. Boys of greater strength participated more frequently in games and activities requiring marked muscular strength and large-muscle coordination. The conclusion of the author is that muscular inadequacy and incompetency prevent boys from successfully participating in organized games which require better than average strength.—*Carolyn W. Bookwalter.*

PHYSIOLOGY

Taylor, Clara M., Mina W. Lamb, Mary E. Robertson, and Grace MacLeod, "The Energy Expenditure for Quiet Play, and Cycling of Boys Seven to Fourteen Years of Age," *J. Nutrition*, 35: 4 (April, 1948).

Seventy determinations of energy expenditure for quiet play and 61 for cycling by 22 subjects, 7 to 14 years of age, are reported. A respiration chamber equipped with a bicycle ergometer of electric brake type was used. Nineteen determinations were made on boys 7 and 8 years of age. Sitting quietly at play the average energy expenditure of these boys per hour was 3.1 calories per kilogram, or 0.59 calories per centimeter of height; for cycling, 6.6 calories per kilogram, or 1.23 calories per centimeter of height; increases above the average basal metabolism were 55 and 230%, respectively. Twenty-nine determinations in quiet play and 20 for cycling were made on boys 9 to 11 years of age. For quiet play the average expenditure per hour was 2.6 calories per kilogram, or 0.58 calories per centimeter of height, for cycling, 5.1 calories per kilogram, or 1.15 calories per centimeter of height; increases above the average basal metabolism were 63 and 219%, respectively. Twenty-two determinations were made on boys 12 to 14 years of age. For quiet play the average per hour was 2.1 calories per kilogram, or 0.58 calories per centimeter of height; for cycling, 4.5 calories per kilogram, or 1.24 calories per centimeter of height; increases above the average basal metabolism was 62 and 246%, respectively.—*Wistar Institute.*

Morrison, Peter R., "Oxygen Consumption in Several Small Wild Mammals," *J. Cell. and Comp. Physiol.*, 31:1 (February, 1948).

Oxygen consumption in a series of 13 different, small, wild mammals

has been studied during 24-hour periods using an automatic volumetric apparatus particularly designed for this group. These included very different types: bats, shrews, squirrels, and mice, as well as closely related forms. The following genera were represented: Sorex, Blarina, Myotis, Eptesicus, Glaucompys, Peromyscus, Microtus, Pitymys, and Mus. The condition of measurement simulated natural conditions in that animals were provided with ample food and water and were not disturbed by circulating air. The 24-hour record quantitatively describes fluctuations in the level of activity during the day. In some animals almost identical records were obtained in duplicate runs on individuals. Others were less dependable. The various species were grouped and differentiated in respect to the following characters of the record: (1) the amplitude and frequency of the short cycle; (2) the amplitude and position of the 24-hour cycle; the times of minimum and maximum oxygen consumption; (3) the values of minimum, average, and maximum oxygen consumption. On the basis of these qualitative and quantitative criteria the various species could be separated from one another and into groups which followed in general their taxonomic relationships.—*Wistar Institute.*

Keys, A., A. Henschel, and H. L. Taylor. "The Size and Function of the Human Heart at Rest in Semi-Starvation and in Subsequent Rehabilitation," *Am. J. Physiol.*, 150 (July, 1947), pp. 153-169.

This study was conducted at the Minnesota Physiological Hygiene Laboratory on 32 volunteers who were subjected to semi-starvation diets for a period of 24 weeks and a subsequent rehabilitation period of 12 to 32 weeks.

Contrary to a commonly accepted notion, this investigation presents clear evidence of decreases in size and function of heart during inanition. Measurements on roentgenkymograms taken after 24 weeks of semi-starvation diet, which reduced the body weight by 25 per cent, found the mean transverse diameter of the heart had decreased 12.3 percent. Pulse rate dropped 33 percent and stroke volume of the heart was reduced 18 percent. Other conditions noticed during the semi-starvation period were: weakness, fatigue, edema, depression, and cyanosis. Protein or vitamin deficiencies were not evident.

During the first 12 weeks of rehabilitation, the 32 subjects were divided into 4 groups and placed on diets which contained 2,464 calories (basal), 2,864 calories, 3,264 calories, and 3,664 calories. Restoration of body weight, systolic arterial pressure, and basal pulse pressure varied directly with calorie level of diet. Recovery of basal heart rate and blood hemoglobin concentration was independent of differences in calorie intake. Recovery of venous blood pressure followed an irregular pattern. No consistent evidence was observed regarding protein or vitamin content of diets during rehabilitation.—*Richard I. Miller, Springfield College.*

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Ogden, Jean, and Jess Ogden. *Small Communities in Action.* New York City: Harper & Brothers, 1946. (books)

Deaver, G. G. Exercise and heart disease. *Research Quarterly,* 10:24-34, 1939. (periodicals)

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